

Food Consumption, Paternalism and Economic Policy

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Abstract

The thesis consists of a summary and four papers, concerned with food consumption, behavior associated with overconsumption of food and analysis of the economic policy reforms designed to improve health.

Paper [I] estimates a hedonic price model on breakfast cereal, crisp bread and potato product data. The purpose is to examine the marginal implicit prices for food characteristics associated with health. A trade-off exists between health and taste. For instance, sugar, salt and fat are tasty but can be unhealthy if overconsumed; whereas fiber is unhealthy if underconsumed. If the marginal implicit price for sugar is negative, consumers value health over its taste. Our results are the marginal implicit price for sugar is negative for breakfast cereals and crisp bread—consumers value health over the taste of sugar. For salt, we find the opposite—a positive marginal implicit price, suggesting people value its taste over health. For fat, we find a negative marginal implicit price of fat in breakfast cereals and potato products containing salt, whereas we find a positive marginal implicit price of fat in hard bread and potato products that contain no salt. For the one healthy characteristic, fiber, we find a negative marginal implicit price in breakfast cereals and a positive implicit price in hard bread.

Paper [II] uses a general equilibrium model to derive the optimal policy if people overconsume unhealthy food due to self-control problems. Individuals lacking self-control have a preference for immediate gratification, at the expense of future health. We show the optimal policy to help individuals with self-control problems to behave rationally is a combination of subsidies for the health capital stock and the physical capital stock.

Paper [III] estimates a demand system for grain consumption based on household panel data and detailed product characteristics, and simulate the effect on grain consumption of economic policy reforms designed to encourage a healthier grain diet. Our results imply it is more cost-efficient to subsidize the fiber content than to subsidize products rich in fiber given the goal to increase the fiber intake of the average Swedish household. Our results also imply subsidies alone give rise to an increase in fiber, and to other unhealthy nutrients. Also, subsidies alone have negative effects on the budget. We therefore simulate the effect of policy reforms in which the subsidies are funded either by taxes on the content of unhealthy nutrients or by taxes on products that are overconsumed. Our results suggest that price instruments need to be substantial to change consumption. For instance, removing the VAT on products rich in fiber has little effect on consumption.

Paper [IV] explores habit persistence in breakfast cereal purchases. To perform the analysis, we use a mixed multinomial logit model, on household panel data on breakfast cereal purchases. If habit persistence in consumption is strong, short and long-run responses to policy reforms will differ. Our results are breakfast cereal purchases are strongly associated with habit persistence. Our results also imply preferences for breakfast cereals are heterogeneous over households and the strength of habit persistence is similar over educational and income groups.

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Umeå, May 2008
Linda

This thesis consists of a summary and the following four self-contained papers:

[I] Thunström, L. (2007) The Marginal Willingness-to-Pay for Health Related Food Characteristics, *Umeå Economic Studies No. 724* (revised)

[II] Aronsson, T. and Thunström, L. (2008) A Note on Optimal Paternalism and Health Capital Subsidies. Mimeo

[III] Nordström, J. and Thunström, L. (2007) The Impact of Tax Reforms Designed to Encourage Healthier Grain Consumption, *Umeå Economic Studies No. 717* (revised)

[IV] Thunström, L. (2008) Preference Heterogeneity and Habit Persistence: The Case of Breakfast Cereal Consumption, *Umeå Economic Studies No. 738*

1. Introduction

This thesis consists of four papers, all concerning different aspects of modern food consumption. Paper I investigates the marginal willingness-to-pay for healthy and unhealthy food characteristics in breakfast cereals, crisp bread, and potato products. In Paper II, a theoretical model is constructed to analyze the policy implications of potential behavioral failures associated with overconsumption of unhealthy food (so-called self-control problems). Paper III analyzes the effect on food consumption and tax revenues of imposing taxes on particularly unhealthy food products or ingredients, while subsidizing healthy food products, based on data on grain consumption. Finally, Paper IV analyzes the strength of food habits through a panel on breakfast cereal consumption.

In most Western countries, as well as in many transition economies, the prevalence of illnesses related to the modern diet and a more sedentary lifestyle has increased markedly over the last few decades. The modern diet is often rich in empty calories and fat, and has proven to be a significant risk factor for several types of cancer, cardiovascular disease, diabetes, osteoporosis, and dental caries as well as overweight and obesity, themselves major risk factors of many of these diseases. The most rapid increase in obesity and overweight has been in the U.S., where now about one third of the adult population is overweight (with a Body Mass Index, BMI, of 25-30), one third is obese (with a BMI greater than 30), and one third is normal or underweight (BMI less than 25). The corresponding figures for Sweden are more modest: around 10 percent of the adult population is obese, but the trend is concerning. Since 1980, the proportion of obese adults in the population has doubled, and the most rapid increase has been among the younger adult population. Since the 1980s, there has also been a steady increase in many illnesses related to

poor diet, such as cardiovascular diseases, respiratory illnesses, and diabetes (Statistics Sweden).

Developments are similar in other Western countries. The World Health Organization notes "...improving nutrition could be the single most important contributor to reducing the burden of disease in the WHO European Region" (WHO, 2004, p.27). Poor diet is estimated to cause, for example, about one third of European cancer deaths and one third of cardiovascular diseases. Cancer and cardiovascular diseases account for almost two thirds of Europe's total disease burden, as measured by losses of years of healthy life (WHO, 2004).

In the last decade, the phenomenon of poor nutrition has received the attention of economists, as a behavioral, health, and public finance issue. Poor nutrition has been acknowledged as an economic problem primarily for three reasons. First, poor nutrition may be driven by developments in economic variables, such as technological change and falling relative prices. Second, poor nutrition might result from individuals not being fully rational. If this is the case, government intervention could be justified as a means of correcting this behavioral failure, which is interpreted as a paternalistic motive for public policy. The underlying behavioral failure is often exemplified by a self-control problem, caused by quasi-hyperbolic discounting. If individuals suffer from self-control problems, they impose negative externalities on their future selves. Third, poor nutrition may also give rise to externalities: for instance, through an increased fiscal burden on taxpayers or lost production due to sick-absenteeism.

In the U.S., direct costs on healthcare (costs of in- and outpatient care and pharmaceutical therapy) from poor nutrition and insufficient exercise are estimated to account for 7 percent of personal healthcare expenditures (Kenkel and Manning,

1999). In Sweden, direct and indirect costs¹ solely of obesity and overweight (i.e., disregarding all other illnesses caused by poor nutrition) have been estimated at SEK 3.6 billion (Persson et al. 2004) and SEK 12.4 billion (Persson and Ödegaard, 2005), which is about 3 percent of the total costs (direct and indirect) of all illness (Socialstyrelsen, 2003). These costs may be even higher in the future due to the time lag between the prevalence of obesity and overweight and the serious illnesses that often follow.

2. Drivers behind the increase in diet-related illnesses

Most of the economic studies on diet-related illnesses are concerned with obesity and overweight. If there is an imbalance between the intake of calories and the expenditure of calories, body weight will increase. The increase in obesity and overweight over the last few decades could therefore be caused either by an increase in the intake of calories, or a decrease in physical activity, or both. Cutler et al. (2003) conclude that the rise in obesity in the U.S. is primarily a result of an increase in caloric intake, and that this increase in the intake of calories is in turn driven by technological change (in production, storage and transportation), enabling a greater availability of unhealthy food at lower prices. Chou et al. (2004) and Philipson and Posner (1999) also point to these factors as important explanations for the positive trend in obesity and overweight in the United States. Further, Philipson and Posner argue that the impact of technological change on physical activity is also important: both market and household production are less physically demanding today than a few decades ago, for instance due to greater technological advances in production machinery, household appliances, storage possibilities, and transportation.

¹ Here, indirect costs are defined as the value of lost production, sick leave, disability pension, and early death.

Another aspect of technological change is that it has enabled production of food that is tastier than ever before, for instance due to the increased availability of a wide range of chemical and non-chemical taste enhancers, aromas, preservatives, and ingredients affecting the texture of food. Birch (1999) and Smith (2004) suggest that it is the ability of modern food production to exploit consumer preferences for energy-dense food that has led to the increased intake of calories. Evolution shaped our preferences for ingredients in food, where taste is the tool we use to gain information on its nutritional value. We prefer fatty, sweet, and salty foods, since fat is energy dense, sweet foods (e.g., fruits and berries) contain important vitamins and antioxidants; and salt is vital to maintaining the chemical balance in the body. Modern foods are fatter, sweeter, and saltier than ever before, and tastes are enhanced both by adding more of these ingredients, and by the addition of chemical taste enhancers. However, nutritional value is often lost in food processing. Relying on taste as the sole source of nutritional information today might therefore be misleading or, in the worst case, even put our health at risk, by encouraging a large intake of so-called empty calories (food high in calories but low in nutritional value). In modern societies, food consumption is, therefore, often associated with a trade-off between taste and health.

We find fatty, salty, and sweet foods tasty, but a high consumption of these ingredients is at the same time associated with health risks. It is not known a priori whether taste or nutrition (health) is the dominant factor for consumers when valuing these ingredients. If taste dominates for some ingredient (for instance fat), consumers will value more fat in the food product, i.e., have a positive marginal willingness-to-pay for fat. If, on the other hand, nutrition outweighs taste, consumers will attach a negative value to adding more fat to the food product, i.e., their marginal willingness-to-pay for fat will be negative (an argument that is based on the fact that most consumers overconsume fat, particularly saturated fat). If we

want to understand the drivers of obesity, we need to learn more about how consumers value food characteristics that increase taste and health risks at the same time. The values that consumers attach to food characteristics also affect food supply by giving firms incentives or disincentives to supply healthy food.

The values that consumers attach to characteristics in food have been studied on U.S. data by Stanley and Tschirhart (1991) and Shi and Price (1998), who use the hedonic price method to estimate consumers' marginal values of characteristics in breakfast cereals. Stanley and Tschirhart focus on the estimation of a hedonic price function for a non-durable good, using nutritional data on breakfast cereals. Shi and Price analyze how sociodemographic variables (income, level of education, number of children, and age) affect the values attached by consumers to characteristics of breakfast cereals, including non-nutrient characteristics such as type of grain. They find that energy (calories) is positively valued, at the margin, by all consumer groups, whereas fat is negatively valued at the margin, as is fiber. Both Stanley and Tschirhart and Shi and Price find a positive effect of sugar on the price of breakfast cereals, and Stanley and Tschirhart find a negative effect of fiber.

In Paper I, we extend these studies by analyzing Swedish households' marginal willingness-to-pay for health-related food characteristics in breakfast cereals, crisp bread, and potato products. Our aim is to determine whether increasing the content of health-related food characteristics is positively or negatively valued by the average household, thereby impacting positively or negatively on the willingness-to-pay for these characteristics.

Paper [I] The Marginal Willingness-to-Pay for Health Related Food Characteristics

The purpose of this study is to estimate the marginal values attached by consumers to particularly health-related food characteristics: fat, fiber, salt, sugar, and the nutrition symbol². The values are measured by the marginal willingness-to-pay, i.e., the marginal implicit prices, for these food characteristics.

In this study, hedonic price models (see e.g., Lancaster, 1966, Rosen, 1974) are used to calculate the marginal implicit prices of the characteristics; the data consist of prices and ingredients in a sample of breakfast cereals, crisp bread, and potato products. These data were provided by AC Nielsen and GfK Sweden: the AC Nielsen data consist of scanner data, and the GfK data set is an extract from the GfK household panel. The three product groups were chosen for two reasons: they constitute important parts of the modern diet in Sweden, and each of these groups contains a wide variety of products that differ substantially in their nutritional content while still being close substitutes.

A positive mean marginal implicit price of a particularly unhealthy ingredient – fat, sugar, or salt – is interpreted to mean that, for the average consumer, taste outweighs health for that particular ingredient. For instance, if consumers are willing to pay (i.e., attach a positive marginal implicit price) to the addition of more fat to a product, the taste-enhancing effect of adding more fat outweighs the negative effect on the health status of the product from the extra fat. A positive marginal implicit price of the nutrition symbol means that consumers value the easily accessible nutritional information provided by the symbol.

² The Swedish National Food Administration certifies products categorized as particularly healthy with a nutrition symbol, the “Keyhole,” based on specific criteria that vary across food groups.

Calculating the mean marginal implicit prices for fat, fiber, salt, and sugar in breakfast cereals, crisp bread, and potato products, our results imply that the dominance of taste over nutrition, or vice versa, varies both across characteristics and across food products. Nutrition (health) outweighs taste for fat in breakfast cereals and in potato products that contain salt, whereas taste outweighs nutrition for fat in crisp bread and in potato products that do not contain salt. Taste also outweighs nutrition for salt in breakfast cereals and crisp bread, resulting in a positive mean marginal implicit price (or marginal willingness-to-pay) for salt in these products. For salt in potato products, the results imply the reverse, however. For sugar in breakfast cereals and crisp bread, nutrition seems to outweigh taste, resulting in a negative marginal willingness-to-pay for sugar in both breakfast cereals and hard bread. As for the one particularly healthy ingredient, fiber, the marginal willingness-to-pay for fiber in breakfast cereals is estimated to be negative, whereas the reverse appears to be the case for crisp bread. Many of the estimated parameters are not statistically significant, though. Therefore, results should be interpreted with caution.

A sensitivity analysis is performed, in which it is shown that the marginal implicit prices for fat, fiber, salt, and sugar are sensitive to the levels of both the ingredient itself and of other food characteristics. A negative marginal willingness-to-pay for a characteristic that is calculated on the basis of the mean contents of the product might thus turn positive with a different combination of food characteristics in the product. If, for instance, the marginal willingness-to-pay for a healthy ingredient (fiber) is positively affected by adding an unhealthy ingredient (such as salt), producers would have an incentive to add salt to products rich in fiber. However, because of the low statistical significance of individual parameters in the hedonic regressions, it is important to exercise caution in interpreting the results of this sensitivity analysis.

Surprisingly, the nutrition symbol on breakfast cereals is found to have a negative marginal implicit price, whereas the effect on price of the nutrition symbol on crisp bread could not be statistically confirmed (there are no examples of potato products with the nutrition symbol in the data set). The average consumer thus seems to provide producers with disincentives to apply for certification for the nutrition symbol. A negative marginal implicit price for the nutrition symbol seems counterintuitive; if, however, consumers on average regard the nutrition symbol not only as a source of information, but also as a sign of poor flavor, this result could be expected.

3. Self-control problems in a world of temptations

In a world full of tasty temptations, individuals with self-control problems will find it especially difficult to restrict their present consumption of tasty food and thereby gain future health. In standard economic models, individuals are assumed to discount future utilities by a constant discount rate (with an exponential discount function), which leads to time-consistent choices if preferences are stable over time. The behavioral pattern implied by exponential discounting is here defined as rational. An individual with self-control problems, on the other hand, has a present bias, i.e., is too prone to immediate gratification: the discount rate between today and tomorrow is higher than the discount rate between tomorrow and future time periods. Such discounting is also referred to as hyperbolic, and the implications of hyperbolic discounting on savings behavior have previously been studied (e.g., Laibson, 1997, 1998, and Fischer, 1999). In order to establish a self-control problem, the hyperbolic discounting has to be regarded as undesirable in the longer perspective, such that short-term actions undertaken by an individual (e.g., eating a pizza) do not comply with the individual's long-term goals (a stable body weight).

If individuals suffer from self-control problems, and do not commit themselves to follow their longer term goals, their behavior might not maximize their own welfare in the longer time perspective.

Individuals who are unaware of the persistence of their self-control problem over time, i.e., believe that they will behave differently tomorrow, have been referred to as “naïve”, whereas individuals who are aware of the persistence of their self-control problem have been referred to as “sophisticated” (O’Donoghue and Rabin, 1999). By not acknowledging that they suffer from self-control problems, naïve individuals will not commit their future selves to behave rationally, while sophisticated individuals may decide upon a consumption plan that their future selves will follow.

Policy implications of self-control problems associated with unhealthy consumption have been studied primarily by O’Donoghue and Rabin (1999, 2003, 2006). The authors construct a theoretical model in which they derive an optimal commodity tax on unhealthy food, to correct for the self-control problem and provide individuals with economic incentives to behave time-consistently. The motive for implementing the tax is, therefore, paternalistic: the tax helps individuals with self-control problems to maximize their own welfare in a longer time perspective. O’Donoghue and Rabin (2006) also show that even if there is a relatively low prevalence of self-control problems in the population, optimal corrective commodity taxes may still be large.³

³ O’Donoghue and Rabin show that if half the population is fully rational and the other half has a relatively small present bias (the extra discount factor between today’s utility and future utility that represents the present bias amounts to 0.9), the optimal tax on unhealthy food may amount to almost 65 percent.

However, in the models used by O'Donoghue and Rabin, health is modeled in a similar way to a flow variable, which will have implications for the optimal policy derived. Modeling health as a capital concept (see e.g., Grossman, 1972) adds more realism to the model, thereby allowing health to be determined by the accumulated actions individuals have taken in the past. In Paper II, we construct a model where health is a capital concept, and analyze the resulting implications for the optimal policy that corrects for the behavioral failure associated with the self-control problem.

Paper [II] A Note on Optimal Paternalism and Health Capital Subsidies

This paper is based on a dynamic general equilibrium model, where health is treated as a capital concept. The instantaneous utility facing the individual is a function of the current consumption of healthy and unhealthy food as well as of the stock of health capital. The stock of health capital is determined by all previous consumption of unhealthy food as well as all previous private investments in health. In line with previous studies, social optimum is achieved by utility maximization with exponential discounting, given the restriction presented by available resources.

Due to the time inconsistency, individuals with self-control problems will overconsume unhealthy food today, at the expense of their future health, thereby imposing negative externalities on their future selves. We assume that the individual is naïve, such that he/she thinks that the self-control problem will vanish in the future. Thus, the individual does not take sufficient actions today to prevent overconsumption, and continues to overconsume the unhealthy food.

Our results suggest that the social optimum can be implemented by a combination of subsidies directed to the stocks of physical and health capital. The intuition is that the externalities that the current self imposes on his/her future selves are stock-externalities. This means that the values the individuals attach to their stocks of physical capital and health capital reflect the preference for immediate gratification. Therefore, the stock-subsidies are designed to make the individuals value physical capital and health capital in the same way as the social planner (for whom the preference for immediate gratification is absent by assumption).⁴

4. Effects of commodity taxes and subsidies on unhealthy and healthy food

From a practical perspective, however, it might be easier to communicate and implement commodity taxes, or commodity subsidies, than subsidies directed towards the health capital. Taxes on unhealthy food have already been introduced in some countries and regions. For instance, some U.S. states have imposed a small tax on soda and other foods of low nutritional value. Norway and Denmark, too, have small taxes on soda, though for historical reasons. By estimating own price, cross price and income elasticities for food, we gain information on how much demand for a particular food (for example snacks) would change if the price was increased (for instance, due to a tax on snacks).

⁴ In a longer version of the note (Aronsson, T. and Thunström, L., 2005) we also briefly discuss the situation with “sophisticated” consumers (who recognize that they suffer from self-control problems and will do so in every time period) as well as discuss the welfare effect of implementing a tax on unhealthy food. In particular, since the externalities that the current self imposes on his/her future selves are stock-externalities, these cannot be fully internalized by taxing the consumption of unhealthy food.

The literature on food demand has primarily been concerned with estimates of own price elasticities. These estimates are typically low, often between -0.8 and -0.2 (see e.g., DEFRA, National Statistics, 2000, Seale et al., 2003, Katchova et al., 2005, Kuchler et al., 2005, Chouinard et al., 2007). Seale et al. (2003), who estimate price elasticities of different food groups in 114 countries, show that own price elasticities are smaller for staple goods (e.g., cereals) than for higher-value foods (dairy products and meat). They also show that own price elasticities are similar across most Western countries, but that for poorer countries own price elasticities of food are slightly larger. On a micro level, this pattern is confirmed by Jensen and Smed (2007), who use Danish data to analyze the price sensitivity of food, showing that the own price elasticities for food are higher for lower income groups.

In order to estimate effects of price changes that could be used to evaluate tax reforms designed to encourage healthier food consumption, it is useful to disaggregate and divide data into healthy and unhealthy food. The most comprehensive empirical study to date on the impact of commodity tax reforms aimed at encouraging a healthier diet is Smed et al. (2007). They use detailed household and product data from the market research company GfK Denmark, combined with nutritional information on the products purchased by the households, to estimate a demand system for food consumption. Based on the estimation results, Smed et al. (2007) also analyze the effects of imposing taxes on unhealthy commodities, subsidies on healthy commodities, and reforms entailing taxes on unhealthy ingredients and subsidies on healthy ingredients.

In Paper III, we perform a similar study on Swedish data, restricted to grain products. We analyze how economic policy instruments can be used to direct consumption towards the nutritional recommendations of the Swedish National Food Administration (*Livsmedelsverket*, SLV).

Paper [III] The Impact of Tax Reforms Designed to Encourage Healthier Grain Consumption

In this paper, we estimate a demand system for grain products and use these results to simulate the effects of economic policy reforms designed to guide the food consumption of the average household to levels recommended by the SLV.

A high intake of dietary fiber promotes health in several ways – by helping to maintain a healthy body weight (Burton-Freeman, 2000, Liu et al., 2003) and by controlling and preventing heart diseases (Liu, 1999, Mann, 2002), diabetes (Brand-Miller et al., 2003, Schulze et al., 2004, Willet et al., 2002), and colorectal cancer (Schatzkin et al., 2007). The health benefits of a fiber-rich diet have led the Swedish National Food Administration (SLV) to recommend that the average Swedish consumer greatly increases his/her fiber intake. The SLV recommends that the average woman should increase her fiber intake by a minimum of 56 percent, and the average man by a minimum of 38 percent.⁵

Grain products are, along with fruit and vegetables, the most important source of dietary fiber. Grain products are also the food group that contributes most to our daily energy intake, as well as perhaps containing the greatest variety of food products.⁶ Whole grain products in particular are considered part of a healthy diet,

⁵ The average woman consumes 112 grams of dietary fiber per week, whereas the average man consumes 126 grams (Becker and Pearson, 2002). Recommended weekly levels are 175-245 grams of dietary fiber for both sexes (SNR, 1997). To reach the lower bound of the recommended interval, the average woman and man would have to increase her/his intake of dietary fiber by 56 percent and 38 percent, respectively.

⁶ According to statistics collected by the Swedish Board of Agriculture, the consumption of grain products constitutes around a third of the total daily energy intake of the average Swedish consumer. In 2003, grain products made up 18 percent of total food expenditures, while food expenditures constituted 12 percent of total household expenditures (Statistics Sweden, Household Budget Survey, 2003).

whereas white, highly refined grain products are often classified as “empty calories”, food that is energy dense but low in nutritional content.

Our analysis is based on the assumption that the aim of policy makers is for the average consumer to reach the nutritional recommendations stated above, i.e., an increase in fiber intake from grain consumption of at least 38 percent.⁷ To translate this into recommendations for grain product consumption, the SLV recommends that the average person (a) doubles her overall intake of bread and breakfast cereals, while (b) ensuring that half of the bread and breakfast cereals consumed bears the nutrition “Keyhole” symbol certified by the SLV (SNÖ, 2003).

To perform the analysis, we estimate a demand system for grain products using a Quadratic Almost Ideal Demand System (QAIDS). The demand system is estimated in multiple steps, where the grain products are grouped according to characteristics. The results from the QAIDS are used to simulate the outcome of different policy reforms. We use three data sources in the analysis: an extract on grain consumption in 2003 by households in the GfK household panel, an extract on household bread consumption in 1996 from Statistics Sweden, and nutritional data from the macro nutrient database maintained by the SLV. The level of product detail in the GfK household panel allows us to link each grain product with its nutritional content, as defined by the SLV macro nutrient database.

For the average household to achieve a higher fiber intake, we simulate the effects of introducing a commodity subsidy on products rich in fiber as well as a subsidy

⁷ It is worth mentioning that the recommended increase in the fiber intake is general and considers all food groups, i.e., it is not specific to grain consumption. Since we are only able to analyze grain consumption, we assume that policy makers wish to encourage consumers to increase their fiber intake from all product groups by the same proportion. For simplicity, we therefore set the policy objective at a minimum of a 38 percent increase in fiber intake from grain products for the average consumer, i.e., regardless of gender.

of the fiber content. Our results imply that while both of these interventions lead to increased fiber intake, the subsidy on the ingredient itself is more cost-efficient than the commodity subsidy. However, for the average household to attain the recommended increase in fiber intake of 38 percent, the results from our model suggest that subsidies have to be substantial: for instance, a commodity subsidy of 50 percent on products rich in fiber. Our results also show, however, that subsidies in isolation not only increase the intake of the healthy ingredient (fiber), but also yield unwanted intakes of the more unhealthy ingredients (fat, sugar, and salt) due to the income effect. This is in line with the findings of Jensen and Smed (2007). In addition, subsidies in isolation may lead to a budget deficit: therefore, subsidies on healthy food need to be combined with taxes on unhealthy food that counteract the increased intake of unhealthy ingredients, and balance the national budget.

In our model, a policy reform that achieves both a sizeable increase in fiber intake and balances the budget would be a 50 percent subsidy of Keyhole labeled bread and breakfast cereals, funded by a 114 percent commodity tax on bakery goods and ready-to-eat meals. This approaches Swedish tax levels for tobacco. The increase in fiber intake from such a funded subsidy reform is substantial. However, increases in other (unhealthy) nutrients remain sizeable, even if reduced compared to the reform with the unfunded subsidy.

We also find that the funded subsidy reform results in a price level, for the average consumer, of grain products amounting to 97 percent of the baseline level (i.e., the ex ante price level).

5. Habit formation in food consumption

If consumption were associated with habit persistence, adjustment of consumption would be slower, as income, information, and prices are changed. This would mean that the tax reforms discussed in Paper III would have little effect on food consumption patterns in the short term, but may have a larger effect on food consumption in the long run. It would also mean that information (for instance promotion of new dietary guidelines) would have little effect in the short run, compared to if consumption were not habitual.

Despite the important implications of habit persistence, research on habits in consumption is relatively limited. Further, the studies performed have largely been based on aggregate data, probably because of a lack of access to adequate micro level data (Browning and Collado, 2007, Carrasco et al., 2005). A few studies have focused explicitly on habit formation in consumption using micro level data (e.g., Browning and Collado, 2007, Carrasco et al., 2005, Dynan, 2000, Meghir and Weber, 1996, and Alessie and Kapteyn, 1991). Evidence of habit persistence in food consumption from these studies is mixed. Browning and Collado (2007) find that aggregate food consumed away from home exhibits habit persistence, whereas food consumed at home does not. Carrasco et al. (2005) find evidence of habit formation in aggregate food consumption, whereas Dynan (2000), Meghir and Weber (1996), and Alessie and Kapteyn (1991) do not. However, the level of product aggregation in these studies is high. The results are therefore less useful as a basis for policy design, if policies are to target consumption of certain food categories.

Studies on micro level data that contain measures of habit persistence for a detailed food product level typically use discrete choice models (e.g., Seetharaman, 2004,

Sun et al., 2003, Ailawadi, 1998, Erdem, 1996, and Chintagunta, 1993). The studies cited here are primarily concerned with brand loyalty and use U.S. micro data to analyze brand choices for ketchup, yoghurt, margarine, and peanut butter.⁸ Seetharaman (2004) defines the impact on the propensity to buy a brand previously purchased as “structural habit persistence,” and by that definition the cited studies all report significant habit persistence in consumption. Chintagunta (1993) also finds evidence of preference heterogeneity across yoghurt products.

None of these studies is concerned with the health dimension in food consumption, i.e., that consumption of unhealthy food may be more or less habitual than healthy food, nor do they analyze the heterogeneity in habit persistence across consumer groups. If the habit persistence is heterogeneous, food consumption will be affected differently for different consumers by policy reforms, and by information campaigns designed to affect food consumption. Knowledge of variations in the strength of habit persistence across household types is valuable if one wishes to give priority to certain household types when designing policies. For instance, Nordström and Thunström (2008) show that households with children consume a lower proportion of healthy bread and breakfast cereals than households without children. Encouraging families with children to improve their diets might, therefore, be a priority. Another reason for giving priority to families with children is if habits are formed at an early age and are likely to persist over the course of the individual’s life.

Some recent studies use mixed logit models to estimate preference heterogeneity in food demand: Andersen (2006) estimates a mixed logit model using GfK

⁸ Discrete choice models have also been used to analyze habit persistence in consumption of products other than food. For instance, Johannesson and Lundin (2002) use Swedish data to analyze the choice in drug prescription, and Revelt and Train (1998) use U.S. data to estimate the impact of rebates and loans on consumers’ choice of efficiency level for refrigerators.

household panel data on the demand for eggs, whereas Chidmi and Lopez (2007) and Nevo (2001) estimate mixed logit models based on breakfast cereal scanner data. Neither of the studies allows for state dependence, but all three studies find evidence of heterogeneity in consumer preferences for breakfast cereals.

In paper IV, we analyze the habit persistence associated with breakfast cereal consumption and the heterogeneity in habit persistence across households.

Paper [IV] Preference Heterogeneity and Habit Persistence: The Case of Breakfast Cereal Consumption

This study analyzes consumption choices of various household categories for one of the most important parts of the Swedish breakfast, breakfast cereals. We analyze the degree to which breakfast cereal consumption is habitual, and seek to identify differences in variations in habit persistence across household categories.

Pollack (1970) notes that goods are habit forming, i.e., consumption is driven by habit persistence, if current preferences depend on past consumption. If a good is associated with habit persistence, price changes will lead to changes in consumption, which will lead to changes in tastes, which in turn will lead to further changes in consumption. The present study applies the mixed multinomial logit model (also known as the random parameters logit model) to micro level panel data on breakfast cereal consumption from GfK Sweden, where the current utility of breakfast cereals is modeled as a function of, among other things, past consumption.

Our results imply that one of the most important determinants of breakfast cereal choice is habit. There seems to be a strong element of habit persistence in choice of

breakfast cereal for all breakfast cereal types, healthy as well as unhealthy. However, the strength of the habit persistence varies across household categories. Single (mean) parameters representing habit persistence are, therefore, insufficient in representing all household behavior. Even though the breakfast cereal consumption by the average household is strongly habitual, and most breakfast cereal consumption for most households are habitual, there are households where the consumption appears to be driven by variety-seeking. Here, variety-seeking is defined as households experiencing a negative effect on today's utility from a breakfast cereal type, from previously having purchased the same type of breakfast cereal.

We analyze whether differences in income, education, or the constellation of individuals in the household (i.e., household type) explain at least part of the variation in the strength of habit persistence across households (which would otherwise be interpreted as unobserved heterogeneity). Our results imply that the strength of habit persistence is similar across income groups and across educational groups. However, habit persistence appears to be weaker for households with children compared to those without children. A possible explanation might be that preferences are more heterogeneous in families with children (relative to households consisting of adults only), implying that a wider variety of products are consumed and purchased on different occasions. Therefore, habit persistence may be as strong for individual members of this type of household as for individuals in other household types. If it is the case, however, that habit persistence is indeed weakest for families with children, policy instruments aimed at influencing breakfast cereal consumption will function most efficiently by directing consumption away from sweet cereals, relative to other breakfast cereal types, as families with children are the households that consume most sweet cereals.

The results support the literature finding of habit persistence in food consumption. Our results imply that, when concerned with the consumption of certain food categories, the “stickiness” of consumption, due to habit persistence, should be taken into account. The higher the level of habit persistence, the greater will be the difference between short and long-term consumer responses to relative price changes and information campaigns. As a result, the larger the taxes/subsidies will need to be to redirect consumption in the short term (or, alternatively, the longer it will take for taxes to affect consumption), and the more costly it will be to implement policies that are designed to change food consumption.

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The Marginal Willingness-to-Pay for Health Related Food Characteristics*

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Abstract

With food, consumers often face a trade-off between taste and nutrition. A priori, it is not obvious which would be more important to the average consumer, so it is an empirical question how consumers value food characteristics that simultaneously affect taste and nutritional value. In this paper, Swedish consumer preferences regarding food characteristics in breakfast cereals, hard bread and potato products are analyzed. In particular, the value consumers attach to fat, fiber, salt and sugar is studied, as well as the value of easily accessible nutritional information provided by a nutrition symbol. The equations estimated are derived from a hedonic price model. The price data originates from a household panel and scanner data, whereas the corresponding data on food characteristics was collected manually in supermarkets or from producers. The value consumers attach to food characteristics are found to vary by product and the results also imply that these values could be sensitive to changes in the combination of characteristics in a product.

Keywords: hedonic pricing; willingness to pay; food characteristics

JEL classification: D1; I1

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1. Introduction

Being overweight or obese may contribute to serious health problems, such as diabetes, heart disease, several types of cancer, and muscle disorders, as well as social exclusion, causing individual suffering and imposing substantial costs on individuals and society as a whole.¹ In many parts of the world, overweight and obesity have risen dramatically in recent decades. While the cause has been debated, several studies point to altered eating habits, i.e., higher intake of calories (Putnam et al. 2002, Cutler et al. 2003).

The main objective of this study is to analyse how consumers value health related food characteristics. We do so by analysing how consumers value food characteristics that are highly associated with obesity, i.e. particularly unhealthy food characteristics, such as fat, salt and sugar, as well as health improving characteristics, such as fiber and transparent nutritional information provided by a nutrition symbol. The relationship between these characteristics and over-consumption of food is discussed below.

Birch (1999) and Smith (2004) suggest that the ability of modern food supply to exploit consumer preferences for energy-dense food has led to increased intake of calories. Evolution provided us with means of gaining information as to the nutritional value of food. To be on the safe side, we learned to prefer fatty, sweet, and salty foods, since fat is energy dense, sweet foods (e.g., fruits and berries) contain important vitamins and antioxidants; and salt is vital to maintaining chemical balance in the body. Modern technology in food production has taken fattiness, sweetness and saltiness to new extremes. At the same time, nutritional

¹ Definitions of overweight and obesity are usually based on Body Mass Index (BMI), measured as the weight of a person (in kilograms) divided by their squared height (in meters): a BMI of 25-30 is considered overweight and a BMI above 30 is considered obese.

value is often lost in food processing. As opposed to in pre-industrialized societies, relying on taste as the sole source of nutritional information today might even put our health at risk. Also, food processing has made nutritional information less transparent, since consumers cannot directly observe what is contained in the refined product. Even though nutritional information may be readily available on the food package, collecting information is costly, in terms of time to compare the nutritional information on products and even in learning to understand the information. Consumers often act on incomplete information, which can increase consumption of unhealthy foods (Kin et al., 2000). The easily accessible information provided by nutrition symbols, on the other hand, can contribute to a healthier consumption (Neuhouser et al, 1999).

In industrialized societies, there is a trade-off between taste and health, concerning many types of food. Taste encourages consumption of fatty, salty and sweet foods, whereas health awareness discourages consumption of the same foods. Which of these effects dominates is an empirical question, important to answer if we want to understand what is driving the increase in obesity. The value consumers attach to food characteristics also affects food supply, by providing firms with incentives or disincentives to supply healthy food.

In this paper, hedonic price models are estimated on breakfast cereals, hard bread and potato products, in order to gain knowledge on the value consumers attach to fat, fiber, salt, sugar and a nutrition symbol. These three product groups were chosen for two reasons: they constitute important parts of a modern diet, and each

of these product groups contains a wide variety of products that differ substantially in their nutritional content, while still being close substitutes.²

Hedonic price models, launched by Lancaster (1966) and further developed and formalised by Griliches (1967, 1971) and Rosen (1974), have been widely used to estimate marginal implicit prices of characteristics for which markets do not exist.³ Hedonic pricing methods have been used to calculate implicit marginal prices for characteristics of housing (see, for example, Benson et al., 1998, and Mills and Simenauer, 1996). Other areas of application are computer attributes (Bajari and Benkard, 2005) and lately even the attributes of baseball players (Stewart and Jones, 1998) and the services of prostitutes (Moffatt and Simon, 2004).

Stanley and Tschirhart (1991) and Shi and Price (1998) use the hedonic price method to estimate how consumers value characteristics in breakfast cereals. Stanley and Tschirhart focus on the estimation of a hedonic price function for a non-durable good, using nutritional data on breakfast cereals. Shi and Price analyse how socio-demographic variables (income, level of education, number of children, and age) affect the values attached by consumers to characteristics of breakfast cereals, including non-nutrient characteristics such as type of grain. They find that energy (calories) is positively valued by all consumer groups, whereas fat is negatively valued, as is fiber. Both Stanley and Tschirhart and Shi and Price find a

² Potato products might be the weakest group in terms of close substitutes. Even though mashed potatoes can substitute for French fries and French fries can substitute for potato chips, mashed potatoes might not be considered a (close) substitute for chips.

³ A change in food consumption over the last decades has been the shift away from home-made food to packaged or pre-prepared food. The general increase in consumption of unhealthy food ingredients, such as fat, salt and sugar, is therefore not due to an increase in consumption of these goods in their pure forms, but rather due to the average consumer eating pre-prepared food that contains high amounts of these ingredients. To gain knowledge on how consumers value fat, salt and sugar, it is therefore necessary to analyse them as part of a product, i.e. not settle for the market prices of these ingredients.

positive effect of sugar on the price of breakfast cereals, and Stanley and Tschirhart find a negative effect of fiber.

This study extends these studies in three ways. First, the analysis goes beyond breakfast cereals, by including other staple goods, i.e. bread and potatoes. Second, product characteristics are also combined with national average prices for the specific products, thereby providing a more accurate measure of the dependent variable than Stanley and Tschirhart, who collected the prices for their study from a limited number of supermarkets. Third, this is the first analysis of this type using Swedish data.

The outline of the paper is as follows. Section 2 presents the theory behind hedonic models. Section 3 describes the data, and Section 4 describes the empirical method. Section 5 presents the results, while Section 6 summarizes and draws conclusions.

2. Theoretical model

Suppose that consumers derive utility from consumption of a staple good (e.g., breakfast cereals, hard bread, or potato products) and a composite good (all other consumption). Following the modification by Stanley and Tschirhart (1991) of the work by Rosen (1974), it is assumed that the utility derived from consumption of the staple good depends on the “services” it provides, rather than the quantity consumed. The services provided by staple food are considered to be taste, nutrition, and convenience, where convenience is thought of as being inversely related to preparation time of the food. The utility function of the representative consumer can then be written as

$$U = \tilde{U}(s_1, s_2, s_3, X) \quad (1)$$

where s_1, s_2 and s_3 are the services taste, nutrition and convenience of the staple good, and X is the composite good. Utility is assumed to increase in each argument and to be strictly concave. The services associated with the staple good are, in turn, assumed to be determined by the n characteristics of the particular food product; content of berries, fruit, nuts and vitamins, grams of carbohydrates, fat, fiber, protein, salt and sugar, as well as the amount of kilo joule, presence of the nutrition symbol and preparation time. Let $\mathbf{z} = z_1, \dots, z_n$ denote these characteristics. We can define $s_h = s_h(\mathbf{z})$, for $h = 1, 2, 3$. Each characteristic can affect several services simultaneously and oppositely; e.g., fat might affect taste positively, but the nutritional value negatively. The utility function can therefore be rewritten as

$$U = \tilde{U}(s_1, s_2, s_3, X) = \tilde{U}(s_1(\mathbf{z}), s_2(\mathbf{z}), s_3(\mathbf{z}), X) = U(\mathbf{z}, X) \quad (2)$$

Although utility is assumed to be increasing in all services, it can either increase or decrease in particular characteristics. If, for instance, the negative effect of fat on the nutritional value outweighs its positive effect on taste, utility will decrease in fat.

For simplicity, it is also assumed that the consumer only purchases one unit of the staple good. Normalizing the price of the composite good to one, the individual budget constraint then becomes

$$M = P(\mathbf{z}) + X \quad (3)$$

where M is income, measured in units of the composite good; $P(\mathbf{z})$ is the market price of the staple good, assumed to be a function of the characteristics. The price function, $P(\mathbf{z})$, is continuously differentiable in the elements of \mathbf{z} . Since the staple good is differentiated (for example; there are several types of breakfast cereals with different combinations of characteristics), the market price of the good varies over different types of the staple good. Therefore, the consumer is able to affect the price paid for the good by choosing the levels of characteristics in the good. The market price function itself cannot be influenced by the consumer, however. The utility maximizing consumer thus chooses the level of characteristic i such that

$$p_i = U_{z_i} / U_X \quad i = 1, \dots, n \quad (4)$$

where $p_i = \partial P(\mathbf{z}) / \partial z_i$, $U_{z_i} = \partial U / \partial z_i$, and $U_X = \partial U / \partial X$.

Equation (4) means that the increase in the price of the staple good from adding another unit of characteristic i is equal to the marginal rate of substitution between characteristic i and the composite good. In other words, the consumer chooses a combination of characteristics such that the change in the product price, from a marginal increase in a particular characteristic, equals the marginal willingness to pay for that characteristic.

As mentioned above, the marginal utility of the composite good is positive, but the marginal utility of characteristic i can be either positive or negative since the characteristic can enter several services simultaneously and in opposing ways. Therefore, the marginal implicit price of characteristic i can be either positive or

negative; signing the marginal implicit price of a characteristic is thus an empirical question.

3. Data and expected effects of food characteristics

Data on characteristics (ingredients, nutritional information and the presence or not of a nutrition symbol) has mostly been collected manually from packages in supermarkets in Sweden, but also from producer websites, and sometimes from producers directly. The data set is, therefore, limited to include only observations of staple goods that were either found in the stores when gathering ingredients and nutritional values, or for which the characteristics were available from producers. All in all, there are 86 observations on breakfast cereals, 71 observations on hard bread, and 44 observations on potato products.

Average national prices of top-selling Swedish processed potato products (potato chips, frozen potato products, and mashed potato products) were calculated from scanner data, provided by AC Nielsen Sweden, on weekly total national volume and value sold, week 1 through 42, in 2004. GfK Sweden provided data on prices of breakfast cereals and hard bread from their 2003 household panel (daily observations throughout the full year). Average yearly prices for breakfast cereal and hard bread products are calculated on this data. The price data contained in the GfK household panel reflects the prices faced by panel members when making their purchases. Since this price data consist of prices faced by consumers, it could be affected by the mix of households in the panel. Worth noting is that individuals of age 65 and over are slightly over represented. The data contains no information on for example regional representation.

The national Swedish nutrition symbol; the “Keyhole”, is certified by the Swedish Food Administration, based on certain criteria (see SLVFS 1989:2 and LIVSFS 2005:9). There are no potato products certified with the Keyhole symbol in our sample. The Keyhole symbol was found on a sizeable share of both breakfast cereal products and hard bread, though. For breakfast cereals, the certification criteria of the Keyhole cover fat, fiber (or whole grain), salt and sugar content; for bread, the criteria cover fat, fiber and salt content.⁴

The level of detailed nutritional information varies substantially over products. The Appendix presents summary statistics on the characteristics of all three food groups, and other information that appeared on the product package. All characteristics are measured in grams per 100 gram. For all products, information was recorded on energy density (kilo joules), fat, carbohydrates, and protein. For breakfast cereals and hard bread, sugar and fiber content were recorded as well. This information was lacking for potato products, for which both the sugar and fiber content is low and vary little over products, though. The main unhealthy ingredients in potato products are fat and salt, which were recorded. For breakfast cereals, the presence of berries, fruit, and nuts was collected. For potato products, the time required to prepare the food in the oven was recorded for consistency, even in cases where other cooking alternatives existed (such as micro waving or frying).

⁴ The Keyhole certification criteria were revised in 2005 (LIVSFS 2005:9) and then became stricter than they were before (SLVFS 1989:2). Potentially there could therefore be breakfast cereal or hard bread products in the data that fulfilled the Keyhole certification criteria in 2003, when the price data was collected, that do not fulfill the criteria now and hence were not found to carry the Keyhole symbol when characteristics data was collected in stores. Such products, if any, are expected to be very few, though.

Following Stanley and Tschirhart (1991), Table 1 shows the expected effect on services of each food characteristic included in the regression analysis of particular relevance for health.

Table 1. Expected effects of selected food characteristics on food services

Food characteristic	Service		
	Taste	Nutrition	Convenience
Fat	(+)	(-)	(+)
Fiber	(+/-)	(+)	(+)
Salt	(+)	(-)	(+)
Sugar	(+)	(-)	(+)
Vitamins	no effect	(+)	(+)
Nutrition symbol	no effect	no effect	(+)

Most characteristics in Table 1 are expected to affect more than one service, and in opposing ways. The exceptions are vitamins and the nutrition symbol. Vitamins do not affect taste, and are therefore expected to have a positive effect on overall utility, by affecting both nutrition and convenience positively. They are assumed to affect convenience positively since consuming vitamins as part of food is more convenient than consuming vitamin supplements separately. The nutrition symbol informs consumers about the nutritional (i.e. health) status of the product and, by representing easily accessible nutritional information, thus affecting convenience positively. The nutrition symbol is expected to have no effect on taste or nutrition, since it only reflects the content of other characteristics. For the rest of the characteristics, an expected sign of the effect on utility, and thus the willingness to pay, cannot be determined a priori. For most consumers, fat, salt, and sugar are all assumed to affect taste positively, due to our underlying preferences for sweet, salt

and fatty food, and to simultaneously affect nutrition negatively. Fiber, on the other hand, is expected to affect nutrition positively, while the taste effect is less clear. Even though consumers in modern Western societies more often over consume, rather than under consume, fat, salt and sugar (hence the negative effect on the nutrition service), consumers need a certain minimum intake of energy each day, and preferably also a certain intake of fiber and salt. Therefore, fat, fiber, salt and sugar are also expected to have a positive impact on convenience.

4. Empirical method

Assuming that data was generated as described by the theoretical model, the marginal implicit prices of food characteristics can be estimated from a hedonic price function. The functional form of the hedonic price function is an open question, since economic theory provides no guidance here. Semi-log regressions, or linear or quadratic functional forms of Box-Cox transformed variables, have often been used in hedonic regressions. Cropper et al. (1988) find that the performances of various model specifications in hedonic regressions depend on the quality of the data. They conclude that a linear function of Box-Cox transformed variables performs best under perfect information about relevant characteristics. In the case of omitted variables or proxies, the linear function of Box-Cox transformed variables is outperformed only by a hedonic price function with untransformed variables. However, the use of Box-Cox transformations has been criticized. Cassel and Mendelsohn (1985) conclude that the results from the Box-Cox transformation are both hard to interpret and unstable. Also, even a general form of the Box-Cox transformation is restrictive in that it requires the functional form to be the same for all transformed exogenous variables. The quadratic model provides a flexible functional relationship and, in addition, encompasses the linear-

in-variables model as a special case. The quadratic model is therefore used here. Multicollinearity is severely enhanced if both linear and quadratic terms of the same variables are included in the regression, though. Therefore, the square of the difference between the measured value of a characteristic and the mean value for that characteristic is used instead of a quadratic term of the characteristic. The following hedonic price function is estimated for product group j (where j = breakfast cereals, hard bread or potato products)

$$P_j^k = \alpha_j + \sum_{i=1}^m \beta_{ji} z_{ji}^k + \sum_{i=1}^m \delta_{ji} (z_{ij}^k - \bar{z}_{ij})^2 + \gamma_j \tilde{\mathbf{z}}_j^k + \boldsymbol{\phi}_j \mathbf{D}_j^k + \varepsilon_j^k \quad (5)$$

where P_j^k is the price per 100 gram of product k (where $k = 1, \dots, K$) in group j , m is the number of *continuous* characteristics (of a total of n characteristics) in the product; and \bar{z}_{ji} is the mean content of characteristic i in product group j , i.e.

$\bar{z}_{ij} = \sum_k z_{ij}^k / K$. The vector \mathbf{D}_j^k contains dummy variables for discrete

characteristics (indicators of the nutrition symbol, berries, fruit, nuts and vitamins) as well as indicators of the q brands in the data on product group j . Included in the regression is also a vector of interaction terms, defined as

$\tilde{\mathbf{z}}_j^k = (z_{j1}^k z_{j2}^k, z_{j1}^k z_{j3}^k, z_{j1}^k z_{j4}^k, z_{j2}^k z_{j3}^k, z_{j2}^k z_{j4}^k, z_{j3}^k z_{j4}^k)$, where characteristics 1, 2, 3 and

4 are fiber, salt, sugar and fat, respectively. These terms show how combinations of characteristics particularly associated with the nutritional status of the product are valued by consumers. For example, although fiber alone might not be valued highly, fiber in combination with salt might be, meaning that consumers only value additional fiber highly if the staple good at the same time contains a high amount of salt.

This model specification differs from the one used by Stanley and Tschirhart (1991) mainly in that they estimate a hedonic regression specified as a linear Box-Cox function. The main difference from the model chosen by Shi and Price (1998) is that they estimate a linear regression, using more aggregated food product data, and also include interaction terms with household characteristics. Neither Stanley and Tschirhart nor Shi and Price include interaction terms between variables, or control for brand effects, both of which are done here.

The functional relationship between the product price and characteristics is determined by the statistical significance of the effects of the linear, quadratic, and interaction variables. After estimating the hedonic regressions for each product group as specified by equation (5), *F*-tests were performed to determine whether otherwise statistically non-significant parameter estimates jointly contribute to the explanatory power of the model and therefore should not be excluded from the model. If they did not, as a group, contribute to the explanatory power of the model, they were excluded.

For hard bread, there are values missing on salt and sugar for 22 out of 71 observations. Using the information provided in the data set, conditional means were imputed, based on all other independent variables; missing values were thus estimated by regressing salt and sugar on the remaining independent variables. While admittedly raising the problem of multicollinearity, filling in missing values with the imputed ones produces consistent estimates (Little, 1992). Note that the results from the imputation differed little from estimates produced by replacing missing values with mean values of the available levels of the characteristics.

The Cook-Weisburg test for heteroscedasticity was performed. For breakfast cereals and hard bread, the null hypothesis of homoscedasticity cannot be rejected.

For potato products, it can be rejected, however. As a result, White's heteroscedasticity-consistent estimator of the variance-covariance matrix was used when testing hypotheses for potato products.

A model with each observation weighted by its market share has also been estimated, as a means of ensuring that popular products found in stores be given greater weight in the empirical analysis than products rarely found in the stores, since the latter products would often not be part of the choice set faced by consumers. Since food characteristics were collected manually in stores anyway, the most commonly found products are already highly represented in the data. The results from the weighted regressions thus do not differ much from the baseline hedonic regression and are not reported.

Differentiating equation (5) with respect to the i th characteristic, gives the marginal implicit price of characteristic i in product group j , which we denote p_{ji} . The marginal implicit price of (continuous) characteristic i is then

$$p_{ji}^k = \beta_{ji} + 2\delta_{ji}(z_{ji}^k - \bar{z}_{ji})(1 - 1/K) + \sum_{h=1}^H \gamma_{jh} z_{jh}^k \quad i \neq h \quad (6)$$

where z_1, \dots, z_H are the contents of the H continuous characteristics by which characteristic i interacts. Following Stanley and Tschirhart (1991) and Shi and Price (1998), the marginal implicit prices are evaluated at the mean content of the characteristics in the product group. However, only analyzing marginal implicit prices calculated at the mean contents of the product means missing valuable information on how the willingness to pay for a food characteristic depends on the level of the characteristic contained in the product, and also on the level of other characteristics. Therefore, sensitivity analyses has been performed, to provide

transparent information on the change in the marginal implicit price of selected characteristics from changes in the content of characteristics. Such analyses provide insight into how the trade-off between the taste and health effect from one characteristic can be affected both by the level of the characteristic itself and by the contents of other characteristics.

5. Results

We start by discussing the results from the estimations of the hedonic price function. Thereafter, we continue by analyzing the mean marginal implicit prices, i.e. the marginal implicit prices evaluated at the mean product content, and how they change as the product content (marginally) changes.

5.1 Results from the hedonic price regressions

Tables 2-4 show the results of the hedonic regressions, as specified in equation (5), with explanatory variables that either individually or jointly (as determined by the *F*-test) contribute to explaining variations in the product price. In the following, parameters referred to as having a statistically significant effect are statistically significant at the 5 percent level, unless otherwise stated. When commenting on the results, focus will be on five characteristics, i.e. the nutrition symbol, fat, fiber, salt and sugar. As noted earlier, brand dummies were included as controls in the model, but the effects of these variables are not presented.

The results from the hedonic regression on *breakfast cereals* reveal a statistically significant negative effect on price, at the 10 percent level, of the *nutrition symbol*, which contradicts the a priori expectation about consumers valuing the easily accessible information the symbol presents. The linear term for *fat* has no significant effect on the price, but the quadratic term has a highly significant

negative effect. The same is true for *salt*. Also for *fiber*, the quadratic term has a significant effect, this time positive. The linear and the quadratic term for *sugar* show a positive and decreasing effect on the price, with the parameters of the linear and quadratic terms being highly significant. None of the interaction terms have significant effects on the price of breakfast cereals. Most of the quadratic terms have a significant effect on the price of breakfast cereals, whereas the linear terms do not. An *F*-test value of 2.59 (P-value = 0.01) shows that, as a group, the linear and interaction terms jointly contribute to the explanatory power of the model, and they are therefore included in the model. The explanatory power of the regression on breakfast cereals is high; the R square value being 0.86.⁵

⁵ For comparison with Stanley and Tschirhart, a Box-Cox transformation was performed. The qualitative effects of most explanatory variables remained as in Table 2, with the exception of sugar and vitamins. Also, as shown by an *F*-test, brand dummies strongly enhance the explanatory power of the model. As a comparison, a hedonic price function without brand dummies was also estimated. The signs of parameter estimates statistically significant in the full model were the same, and even the levels of these parameters estimates did not change much, though often the estimates were no longer statistically significant.

Table 2. Results from the hedonic regression on breakfast cereals

Variable	Coefficient	Variable	Coefficient
$Z_{nutritionsymbol}$	-109.01* (-1.90)	Z_{salt}	-26.49 (-0.09)
Z_{vit}	-51.86 (-1.17)	$(Z_{salt} - \bar{Z}_{salt})^2$	-542.99** (-2.06)
$Z_{berries}$	95.06** (3.27)	Z_{sugar}	10.48** (2.76)
Z_{fruit}	15.55 (0.39)	$(Z_{sugar} - \bar{Z}_{sugar})^2$	-0.50** (-3.00)
Z_{nuts}	20.95 (0.44)	$Z_{fat}Z_{fiber}$	-0.11 (-0.07)
Z_{carbs}	3.21 (0.49)	$Z_{fat}Z_{salt}$	13.64 (0.67)
$(Z_{carbs} - \bar{Z}_{carbs})^2$	0.33 (0.80)	$Z_{fat}Z_{sugar}$	-44.32 (-0.60)
Z_{fat}	10.69 (0.39)	$Z_{fiber}Z_{salt}$	8.73 (0.28)
$(Z_{fat} - \bar{Z}_{fat})^2$	-2.22** (-2.58)	$Z_{fiber}Z_{sugar}$	-0.99 (-1.48)
Z_{fiber}	-17.20 (-0.88)	Constant	-154.17 (-0.25)
$(Z_{fiber} - \bar{Z}_{fiber})^2$	2.79** (2.23)	R^2 : 0.86	
$Z_{protein}$	62.07** (4.21)		
$(Z_{protein} - \bar{Z}_{protein})$	-14.14** (-4.71)		

Superscript * indicates that the variable has a statistically significant effect at the 10 percent level and superscript ** indicates that the effect is significant at the 5 percent level; t -values are in parentheses.

For *hard bread* products, the coefficient for the *nutrition symbol* has the expected positive sign, but is not statistically significant. A positive effect from *fat* on price is statistically significant at the 10 percent level. The effect of *fiber* is negative but not statistically significant. Similarly, no statistically significant effect is found for

salt or *sugar*. As with breakfast cereals, none of the interaction terms have statistically significant effects on the price. The large number of non-significant estimates is reflected in the lower explanatory power of the model; R square being 0.63.⁶ The lack of significant parameter estimates could be because there is less variation in the data on hard bread than in that on breakfast cereals and potato products. Hard bread is generally healthy, which is shown by the high proportion of hard bread products being certified with the nutrition symbol (see Appendix). Variables which individually had no significant effect on the hard bread price jointly increased the explanatory power of the model (F -test = 1.72, P-value = 0.09), so they were included in the model.

Table 3. Results from the hedonic regression on hard bread

Variable	Coefficient	Variable	Coefficient
$Z_{\text{nutritionsymbol}}$	131.31 (1.16)	Z_{sugar}	-360.84 (-1.10)
Z_{carbs}	41.05* (1.69)	$(Z_{\text{sugar}} - \bar{Z}_{\text{sugar}})^2$	20.09 (1.39)
$(Z_{\text{carbs}} - \bar{Z}_{\text{carbs}})^2$	3.06 (1.01)	$Z_{\text{fat}}Z_{\text{fibre}}$	-15.20 (-1.56)
Z_{fat}	329.62* (1.83)	$Z_{\text{fat}}Z_{\text{salt}}$	111.30 (0.56)
$(Z_{\text{fat}} - \bar{Z}_{\text{fat}})^2$	-28.32** (-3.00)	$Z_{\text{fat}}Z_{\text{sugar}}$	-9.65 (-0.70)
Z_{fiber}	-83.55 (-0.71)	$Z_{\text{fiber}}Z_{\text{salt}}$	215.12 (1.20)
$(Z_{\text{fiber}} - \bar{Z}_{\text{fiber}})^2$	-2.46 (-0.56)	$Z_{\text{fiber}}Z_{\text{sugar}}$	22.03 (1.05)
Z_{protein}	35.25 (1.00)	<i>Constant</i>	-2053.77 (-0.92)
$(Z_{\text{protein}} - \bar{Z}_{\text{protein}})^2$	-26.59** (-2.04)	R^2	0.63

⁶ The F -test shows that removing the brand dummies from the model does not significantly reduce the explanatory power of the model. Without them, the signs of the statistically significant parameter estimates in the full model are still the same, except for the quadratic term for protein, which is positive, but non-significant.

Table 3 continued:

z_{salt}	-3046.31 (-1.03)
$(z_{salt} - \bar{z}_{salt})^2$	1293.59 (0.30)

Superscript * indicates that the variable has a statistically significant effect at the 10 percent level and superscript ** indicates that the effect is significant at the 5 percent level; *t*-values are in parentheses.

For *potato products*, the quadratic terms for carbohydrates and fat, as well as the linear term for protein, have no individually significant effects on the product price. An *F*-test also reveals that including these terms, as a group, does not increase the explanatory power of the model.⁷ Therefore, they are excluded from the model. For potato products, the positive effect of *fat* on the product price is highly statistically significant. Here, the interaction term between fat and salt is also highly significant, and negative, counteracting the positive effect of fat on the product price. The explanatory power of the reduced regression on potato products is still high; the R square value of the regression amounts to 0.92.⁸

⁷ Brand dummies strongly contribute to the explanatory power of the model, however. Without them, the parameter estimates that are individually statistically significant in the full model are still the same both in sign and level. However, the parameter estimates of the effect from carbohydrates and the quadratic terms for carbohydrates, fat and protein, are statistically significant in the reduced model. All still have the same sign as in the full model, except for the parameter estimate of the effect from carbohydrates.

⁸ A model linear in all variables (with brand dummies) was estimated for comparison, for all product groups. The main difference in the results from estimating the linear model occurred for breakfast cereals; the individual effects on the price of fiber and sugar turned insignificant. Also, there is a prevalence of multicollinearity in the models, although dramatically reduced compared to models where both the linear and quadratic terms of the same variables are included, as indicated by high mean variance inflation factors. However, for breakfast cereals and potato products, in turn removing collinear variables leaves the individually statistically significant parameter estimates almost identical to the estimates provided by the full model. In turn removing the most collinear variables from the hard bread group also leaves the sign of the individually statistically significant parameter

Table 4. Results from the hedonic regression on potato products

Variable	Coefficient
$Z_{prep.time}$	-0.04** (-3.14)
Z_{carbs}	-0.07 (-1.52)
Z_{fat}	0.14** (2.37)
$(Z_{protein} - \bar{Z}_{protein})^2$	-0.14 (-1.54)
Z_{salt}	4.29** (8.58)
$Z_{fat}Z_{salt}$	-0.47** (-6.39)
Constant	20.22** (8.31)
R^2	0.92

Superscript * indicates that the variable has a statistically significant effect at the 10 percent level and superscript ** indicates that the effect is significant at the 5 percent level; *t*-values are in parentheses.

Based on the results shown in Tables 2-4 above, marginal implicit prices are calculated (Table 5, below). The marginal implicit prices are calculated at the mean values of the food characteristics. Mean marginal implicit prices are expressed in öre (100 öre = 1 SEK). For each continuous characteristic, the mean marginal implicit price is the amount that consumers are willing to pay for a small increase of this characteristic above its mean value, all other characteristics being at their mean values. For the nutrition symbol, the marginal implicit price indicates consumers' willingness to pay for having the label on the product.

The mean marginal implicit price of *fat* varies greatly over the three product groups. Consumers seem to value fat in hard bread (149 öre), indicating that the

estimates the same, but the absolute value of those parameter estimates drop by about one third.

positive effect on taste from adding fat outweighs the negative effect on nutrition. The opposite is true for breakfast cereals, shown by its large negative mean marginal implicit price (-863 öre). In potato products, the outcome of the trade-off between taste and nutritional value concerning fat seems to depend on whether or not the product contains salt. If the product contains salt, consumers on average have a negative marginal willingness to pay for fat, whereas consumers on average have a positive marginal willingness to pay for additional fat if the product does not contain salt. With salt, the positive effect on taste from a marginal increase in fat seems to be outweighed by the negative effect on nutrition from decreasing the fat content. In both cases, however, the mean marginal implicit price of fat in potato products is small.

The mean marginal implicit price of *fiber* is positive, but non-significant, for hard bread, whereas for breakfast cereals it was negative. This could imply that marginally increasing fiber above its mean level in breakfast cereals reduces the taste, and that this reduction in taste outweighs the positive effect on the nutrition.

The mean marginal implicit price for *salt* is positive both for breakfast cereals and hard bread, although non-significant for the latter group. For the potato products it is negative, however, though quite small. The values are not strictly comparable, though, since salt is included as a dummy in the hedonic regression on potato products. The negative marginal implicit price therefore reflects a negative willingness to pay for adding salt to potato products that contain no salt.

The mean marginal implicit price for *sugar* in breakfast cereals is negative and fairly large (-294 öre) so the negative effect on nutrition from a small increase in the sugar content outweighs the positive effect on taste. The marginal implicit price for sugar in hard bread is also negative, though non-significant.

Table 5. Marginal implicit prices, evaluated at the mean content

Breakfast cereals		Hard bread		Potato products	
Nutrition symbol	-109.01	Nutrition symbol	131.31	Preparation time	-0.04
Vitamins	-51.86	Carbohydrates	41.05	Carbohydrates	-0.07
Berries	95.06	Fat	149.42	Protein	-0.28
Fruit	15.55	Fiber	17.38	Salt	-3.80
Nuts	20.95	Protein	35.25	Fat	
Carbohydrates	3.21	Salt	300.02	- if salt	-0.33
Fat	-862.77	Sugar	-85.50	- if no salt	0.14
Fiber	-34.53				
Protein	62.07				
Salt	128.51				
Sugar	-293.99				

100 öre = 1 SEK

5.2 Results from sensitivity analysis

Table 6 below shows the effect on the marginal implicit price of selected continuous characteristics from a 1 percent change in the levels of these characteristics.

It is important to exercise caution in the interpretation of the results: the only interaction term with an individually statistically significant effect in the hedonic regressions is the interaction term between fat and salt in potato products. The lack of other individually significant parameter estimates means that the results from the

sensitivity analysis should merely be seen as an illustration of the fact that marginal implicit prices may vary over levels of characteristics.

By using the point estimates in Table 2-4, we find that for breakfast cereals, the marginal implicit price of fat decreases, i.e., becomes more negative, as the level of fat is increased above the mean level. The marginal implicit prices of both salt and sugar in breakfast cereals also decrease as the level of the characteristic itself is increased, suggesting that consumers have a diminishing marginal willingness to pay for these characteristics in breakfast cereals. However, the opposite is true for the marginal implicit price of fiber, which increases as the level of fiber increases by one percent above its mean level. Noteworthy is also that the percentage change in the marginal implicit price as the characteristic itself is increased by one percent seems to be quite small for fat (-0.03 percent) and sugar (-0.06 percent), whereas it is fairly sizeable for fiber (1.21 percent) and especially for salt (-3.01 percent) in breakfast cereals.

In hard bread, there is a diminishing marginal willingness to pay for fat and fiber, whereas the marginal willingness to pay for salt and sugar seems to be increasing, as the level of the characteristic itself increases. Also here, the percentage changes of the marginal implicit prices are the smallest for fat (-1.20 percent) and sugar (1.02 percent), as the content of the characteristic itself is increased by one percent above its mean level, compared to the change in the marginal implicit prices for fiber (-3.88 percent) and salt (4.00 percent) in hard bread.

The results from the sensitivity analysis also suggest that, in both breakfast cereals and hard bread, consumers value salt more if the fiber content increases, and vice versa. This could be interpreted as consumers appreciating the taste enhancing effect from salt even more when the fiber content is high. Bearing in mind that we

are looking at marginal changes, if this result is general, it would mean that producers have an incentive to add salt to products rich in fiber, which would decrease the health status of products with a high fiber content.

The results also imply that consumers value salt more if the fat content raises (at least in breakfast cereals and hard bread) and vice versa. This suggests that the dominance of taste over nutrition is even stronger with higher levels of both fat and salt; a possible interpretation is that the taste sensation of the combination of fat and salt is strong.

Table 6. Marginal implicit price changes from changing levels of health characteristics

	Breakfast cereals	Hard bread	Potato products
Effects on the marginal implicit price of fat			
Mean p_{fat}	-862.77	149.42	-0.33/0.14
Percentage change of p_{fat} if increasing fat by 1%	-0.03%	-1.20%	n.a.
Percentage change of p_{fat} if increasing fiber by 1%	-0.001%	-1.41%	n.a.
Percentage change of p_{fat} if increasing salt by 1%	0.01%	0.35%	n.a.
Percentage change of p_{fat} if increasing sugar by 1%	-1.01%	-0.14%	n.a.
Effects on the marginal implicit price of fiber			
Mean p_{fiber}	-34.53	17.38	n.a.
Percentage change of p_{fiber} if increasing fat by 1%	-0.02%	-2.80%	n.a.
Percentage change of p_{fiber} if increasing fiber by 1%	1.21%	-3.88%	n.a.

Table 6 continued:

Percentage change of p_{fiber} if increasing salt by 1%	0.09%	5.80%	n.a.
Percentage change of p_{fiber} if increasing sugar by 1%	-0.57%	2.79%	n.a.
Effects on the marginal implicit price of salt			
Mean p_{salt}	128.51	300.02	-3.79
Percentage change of p_{salt} if increasing fat by 1%	0.69%	1.19%	-2.13%
Percentage change of p_{salt} if increasing fiber by 1%	0.50%	9.96%	n.a.
Percentage change of p_{salt} if increasing salt by 1%	-3.01%	4.00%	n.a.
Effects on the marginal implicit price of sugar			
Mean p_{sugar}	-293.99	-85.50	n.a.
Percentage change of p_{sugar} if increasing fat by 1%	-1.01%	-0.36%	n.a.
Percentage change of p_{sugar} if increasing fiber by 1%	-0.03%	3.58%	n.a.
Percentage change of p_{sugar} if increasing sugar by 1%	-0.06%	1.02%	n.a.

The marginal implicit prices are in öre.

6. Summary and conclusions

In this study, consumers are assumed to derive utility from food that is tasty, convenient and has a high nutritional value. Often there is a trade-off between taste and nutrition, since food rich in particularly unhealthy ingredients (fat, salt and

sugar) may also be very tasty. We do not know, a priori, whether taste or nutrition dominates to consumers, when valuing these ingredients. If taste dominates for some ingredient, consumers will have a positive willingness to pay for it, whereas if nutrition dominates, their willingness to pay will be negative. The purpose of this study is to estimate the values attached by consumers to particularly health related food characteristics; fat, fiber, salt and sugar and the nutrition symbol.

Calculating mean marginal implicit prices for fat, fiber, salt and sugar in breakfast cereals, hard bread and potato products, we find that the dominance of taste over nutrition, or vice versa, varies both over health characteristics and over food products. Nutrition dominates taste for fat in breakfast cereals and in potato products that contain salt, whereas taste dominates nutrition for fat in hard bread and in potato products that do not contain salt. Taste also dominates nutrition for salt in breakfast cereals and hard bread, resulting in a positive mean marginal implicit price (or marginal willingness to pay) for salt in these products. For salt in potato products, the reverse seems to be true, however. For sugar in breakfast cereals and hard bread, nutrition seems to dominate over taste, resulting in a negative marginal willingness to pay for sugar in both breakfast cereals and hard bread. As for the one particularly healthy ingredient, fiber, the marginal willingness to pay for fiber in breakfast cereals is estimated to be negative, whereas the reverse is true for the marginal willingness to pay for fiber in hard bread. Many of the estimated parameters are not statistically significant, though. Therefore, results should be interpreted with caution.

The marginal implicit prices for fat, fiber, salt, and sugar are sensitive to the levels of both the characteristic itself and other food characteristics. A negative marginal willingness to pay for a characteristic that is calculated on the basis of the mean contents of the product might thus turn positive with another combination of food characteristics in the product. This will affect producer incentives to develop

healthy products. If, for instance, the marginal willingness to pay for a healthy ingredient (fiber) is positively affected by adding an unhealthy ingredient (such as salt), producers would have an incentive to add salt to products rich in fiber. However, it is important to exercise caution in interpreting the results of this sensitivity analysis, due to the low statistical significance of individual parameters in the hedonic regressions. More research is needed in order to understand consumer preferences for combinations of ingredients.

The nutrition symbol helps consumers judge the nutritional status of a product, and the symbol was, a priori, expected to be positively value by consumers. However, the nutrition symbol on breakfast cereals seems to have a negative marginal implicit price, whereas the effect on the price from the nutrition symbol on hard bread could not be statistically confirmed. There are no examples of potato products with the nutrition symbol in our data set. The average consumer thus seems to provide producers with disincentives to apply for certification for the nutrition symbol. A negative marginal implicit price for the nutrition symbol seems counter intuitive. If it would be that, on average, consumers regard the nutrition symbol not only as a source of information, but also as a signal for poor taste, such a result could be expected, though.

The fact that consumers have a negative marginal willingness to pay for some characteristics raises the question of why producers continue offering products with such combinations of characteristics. One reason could be that they have incomplete information on consumer preferences and hence the marginal willingness to pay for attributes. Also, consumer preferences change over time, for instance due to new health findings, and producers might be slow to change their products accordingly. In addition, producers often supply a portfolio of products that vary in contents; the profit maximizing portfolio could include products that

individually yield varying profits. Also, preferences vary over consumers. Therefore, even if the average consumer has a negative willingness to pay for a characteristic, there may be sub-groups of consumers with different tastes, constituting niche markets for producers. Such differences in preferences over socio-demographic groups are confirmed by Shi and Price (1998). Their results show that the value attached to energy (kilo joule) in food varies over age groups, with the young attaching a higher value to energy than older consumers. People with higher education were also found to attach a lower value to fat than other consumer groups. In a similar way, Larsson et al. (1999) found that different consumer groups react differently to the nutrition symbol. If preferences for the nutrition symbol vary, there might be groups with a positive willingness to pay for the nutrition symbol, providing producers with incentives to apply for the certification for the nutrition symbol.

To understand the underlying mechanisms of consumer food preferences and producer incentives as part of the explanation for obesity, more research is needed both on the supply side of the market and on the differences in preferences over consumer groups. These are important topics to address in future research.

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Appendix

Summary statistics for food products

	Breakfast cereals	Hard bread	Potatoes
Price per 100 grams*			
Mean price	4.3 SEK	4.4 SEK	5.3 SEK
Min price	1.7 SEK	1.7 SEK	1.3 SEK
Max price	9.6 SEK	8.7 SEK	10.2 SEK
Kilo joule per 100 grams			
Mean content	1583 KJ	1395 KJ	1308 KJ
Min content	1350 KJ	1103 KJ	240 KJ
Max content	1900 KJ	1720 KJ	2321 KJ
Carbohydrates per 100 grams			
Mean content	69.7 grams	64.7 grams	35.2 grams
Min content	52.0 grams	45.0 grams	12.0 grams
Max content	87.0grams	80.0 grams	59.0 grams
Fat per 100 grams			
Mean content	6.7 grams	3.2 grams	17.2 grams
Min content	0.5 grams	0.3 grams	0.5 grams
Max content	18.0 grams	11.0 grams	38.0 grams
Fiber per 100 grams			
Mean content	7.6 grams	13.9 grams	
Min content	1.0 grams	3.8 grams	n.a.
Max content	20.0 grams	27.1 grams	
Protein per 100 grams			
Mean content	9.0 grams	10.0 grams	4.1 grams
Min content	4.5 grams	3.5 grams	1.5 grams
Max content	16.0 grams	13.0 grams	6.0 grams
Salt per 100 grams**			
Mean content	0.36 grams	0.47 grams	n.a. (dummy)
Min content	0 grams	0.20 grams	(32 obs contain
Max content	0.95 grams	0.80 grams	salt)
Sugar per 100 grams**			
Mean content	19.8 grams	2.2 grams	
Min content	0.8 grams	0.1 grams	n.a.
Max content	44.0 grams	12.0 grams	
Food preparation time			
Mean time			9 min 20 sec
Min time	0 min	0 min	0 min
Max time			60 min
Number of obs with nutrition symbol	18	52	n.a.
Number of obs with berries	18	n.a.	n.a.
Number of obs with fruit	26	n.a.	n.a.

Table continued:

Number of obs with nuts	9	n.a.	n.a.
Number of obs showing vitamin info	43	n.a.	n.a.
Number of brands	14	8	6
Total number of obs	86	71	44

*On October 10 2006, USD/SEK = 7.39. ** For hard bread, there are missing observations of salt and sugar, such that the values presented here are based on both actual and predicted observations of these variables.



A Note on Optimal Paternalism and Health Capital Subsidies*

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Abstract

The starting point for this paper is the potential self-control problem underlying the consumption of unhealthy food. Contrary to earlier studies, our results show that subsidies on wealth and health capital are part of the policy package, which can be used to implement a socially optimal resource allocation.

Keywords: Health; Quasi-Hyperbolic Discounting; Subsidies

JEL Classification: D61; D62; H21; I18

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1 Introduction

This short paper concerns government intervention in an economy where a self-control problem caused by quasi-hyperbolic discounting may lead to excessive consumption of unhealthy food. A similar problem has been addressed by O'Donoghue and Rabin (2003, 2006), who consider a paternalistic motive for optimal commodity taxation. They assume that the instantaneous utility increases with the current consumption of an unhealthy commodity and decreases with the consumption of the same unhealthy commodity in the previous period. The latter serves to capture future health consequences of the current consumption. With a self-control problem, this mechanism also implies that the individual's current self imposes a flow-externality on his/her future selves (as the future welfare effects associated with the current instantaneous consumption are not fully internalized).

We assume that the instantaneous utility depends on the current consumption and on the current stock of health capital, whereas the stock of health capital, in turn, depends on (among other things) all past consumption of the unhealthy good. Therefore, in our model, the externality that the individual's current self imposes on his/her future selves is a stock-externality; an assumption which accords well with standard models in health economics (e.g. Grossman 1972). By using a discrete general equilibrium growth model of Ramsey-type, we show that the policy package that implements the social optimum contains subsidies directed to health capital and wealth; it does not contain a tax on the unhealthy consumption or a subsidy on the resource-flow spent on health.

2 The Model and the Main Results

The consumers are identical and their number normalized to one. The instantaneous utility function (which has conventional properties) is written

$$u_t = u(c_t, x_t, h_t) \tag{1}$$

where c is the consumption of an ordinary (not unhealthy) good, x the consumption of the unhealthy good and h the stock of health capital. The consumer

supplies one unit of labor inelastically in each time period. Following, e.g., Phelps and Pollak (1968), Laibson (1997) and O'Donoghue and Rabin (2003), the intertemporal objective at time t is given by

$$U_t = u_t + \beta \sum_{s=t+1}^{\infty} u_s \Theta^{s-t} \quad (2)$$

where $\Theta^t = 1/(1 + \theta)^t$ is a conventional utility discount factor with utility discount rate θ , whereas β is a time-inconsistent preference for immediate gratification, meaning that $\beta < 1$.

The consumer holds an asset in the form of physical capital, which accumulates according to

$$k_{t+1} - k_t = r_t k_t + w_t - e_t - c_t - x_t \quad (3)$$

in which k is the physical capital stock, w the labor income (or wage rate), r the interest rate and e the private resources spent on health. The prices of the two consumption goods are equal to one. We assume that the consumer treats the paths for w and r as exogenous. The health capital stock accumulates according to the equation

$$h_{t+1} - h_t = g(x_t, e_t) \quad (4)$$

where $g(\cdot)$ is a health production function with the properties $\partial g(x_t, e_t)/\partial x_t < 0$ and $\partial g(x_t, e_t)/\partial e_t > 0$. The initial capital stocks, k_0 and h_0 , are exogenous. As capital depreciation is not important for the results, it is suppressed here.

The goods market is competitive and consists of identical firms, and we assume that the production technology is characterized by constant returns to scale in labor and capital. The production function is written $f(1, k_t)$.

Following O'Donoghue and Rabin (2003), we assume that the consumer is naive in the sense of not recognizing that the preference for immediate gratification is present also when the future arrives. The consequences of this assumption will be discussed below. In each time period, the consumer behaves as if he/she is maximizing equation (2) subject to equations (3) and (4). By combining

the first order conditions for the consumer and the firm, while eliminating the Lagrange multipliers, we can derive for period t

$$\frac{\partial u_t}{\partial x_t} - \frac{\partial u_t}{\partial c_t} + \frac{\partial u_t}{\partial c_t} \frac{\partial g_t / \partial x_t}{\partial g_t / \partial e_t} = 0 \quad (5)$$

$$-\frac{\partial u_t}{\partial c_t} + \beta \frac{\partial u_{t+1}}{\partial c_{t+1}} \Theta \left[1 + \frac{\partial f_{t+1}}{\partial k_{t+1}} \right] = 0 \quad (6)$$

$$-\frac{\partial u_t / \partial c_t}{\partial g_t / \partial e_t} + \beta \left[\frac{\partial u_{t+1} / \partial c_{t+1}}{\partial g_{t+1} / \partial e_{t+1}} + \frac{\partial u_{t+1}}{\partial h_{t+1}} \right] \Theta = 0 \quad (7)$$

where we have used $f_t = f(1, k_t)$ and $\partial f_t / \partial k_t - r_t = 0$ for all t . Finally, by using equation (3) and the zero profit condition, the resource constraint for period t becomes

$$k_{t+1} - k_t = f(1, k_t) - e_t - c_t - x_t, \quad (8)$$

Equations (4)-(8) can be used to solve for the equilibrium values of c_t , x_t , e_t , k_{t+1} and h_{t+1} conditional on k_t and h_t .

Following O'Donoghue and Rabin (2003), we assume that $\beta = 1$ from the point of view of a social planner, meaning that the social objective function can be written as

$$\tilde{U}_0 = \sum_{t=0}^{\infty} u_t \Theta^t \quad (9)$$

The socially optimal resource allocation is derived by maximizing equation (9) subject to equations (4) and (8). The first order condition for the consumption of the unhealthy good remains as in equation (5), whereas equations (6) and (7) will change in the sense that β is now equal to one. For further use, let $\{c_t^*, x_t^*, e_t^*, k_t^*, h_t^*\}$ for all t denote the socially optimal resource allocation.

To implement the social optimum in the decentralized economy, suppose that we were to announce, in each period, that the consumer will receive two subsidies in the next period, which are proportional to the value of private wealth and the stock of health capital¹, respectively, and that the subsidies² are

¹ An externality-based argument for a corrective stock subsidy to human capital is discussed by Aronsson and Löfgren (1996).

² The use of interest rate subsidies to implement different savings policies in an economy

financed by a lump-sum tax. We assume that the consumer treats the subsidy rates and the lump-sum tax as exogenous. Note also that these subsidies must be part of a 'surprise policy' introduced in each period, since the consumer does not expect to be time-inconsistent in the future. Define $u_t^* = u(c_t^*, x_t^*, h_t^*)$ and $g_t^* = g(x_t^*, e_t^*)$ and consider Proposition 1;

Proposition 1 *Suppose that the consumer at any time, t , expects to receive the subsidies $s_{t+1}^*(1+r_{t+1})k_{t+1}$ and $p_{t+1}^*h_{t+1}$ in period $t+1$, while he/she expects to receive no subsidies beyond period $t+1$. If*

$$s_{t+1}^* = \frac{(1-\beta)}{\beta} \text{ and}$$

$$p_{t+1}^* = \frac{(1-\beta)}{\beta} \frac{1}{\partial u_{t+1}^*/\partial c_{t+1}} \left[\frac{\partial u_{t+1}^*/\partial c_{t+1}}{\partial g_{t+1}^*/\partial e_{t+1}} + \frac{\partial u_{t+1}^*}{\partial h_{t+1}} \right],$$

then the equilibrium in the decentralized economy is equivalent to the social optimum.

Each formula in the proposition serves the purpose of eliminating a divergence between an Euler equation associated with the private optimization problem and the corresponding Euler equation resulting from the social optimization problem. The intuition behind Proposition 1 is that the difference between the uncontrolled market economy and the social optimum arises as time-inconsistent individuals underestimate the shadow prices of physical capital and health capital, whereas the private first order conditions for the atemporal control variables (of which x_t is one) take the same general form as their social counterparts. As a consequence, the policy required to internalize the externality that the individual's current self imposes on his/her future selves must be designed to make the individual value physical capital and health capital in the same way as the social planner. The two subsidies described above will have precisely this effect.

Instead of studying naive consumers, another possibility discussed in previous studies is that the consumer is sophisticated³; in this case, he/she recognizes

where (sophisticated) agents have a self-control problems due to quasi-hyperbolic discounting has been addressed by Laibson (1996). Since we are considering health aspects of consumption, our framework differs in a fundamental way from that of Laibson.

³For a more thorough treatment of sophisticated consumers under quasi-hyperbolic dis-

that the future selves will also apply quasi-hyperbolic discounting. Therefore, the best the current self can do is to decide upon a plan, which the future selves will follow. However, even if we were to relax the assumption that the consumer is naive, the basic message of the paper will still be valid in the sense that a combination of subsidies to wealth and health capital can be used to implement the resource allocation that would be chosen by a social planner with exponential discounting. The main difference is that, in the case where the consumer is naive, it was necessary to implement a 'surprise policy', the purpose of which is to address that the consumer, in each period, does not fully understand his/her future decision problem. With a sophisticated consumer, on the other hand, the same policy instruments will be used for a different purpose; to correct for a self-control problem, which the consumer is fully aware of.

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counting, although in a different context than ours, see e.g. Laibson (1997) and Gruber and Köszegi (2001). For an excellent discussion about the distinction between naive and sophisticated consumers, see O'Donoghue and Rabin (1999).

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The Impact of Tax Reforms Designed to Encourage Healthier Grain Consumption^{*}

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Abstract

This paper simulates the effects of reforms entailing subsidies on products and/or nutrients, aimed at encouraging healthier grain consumption. We use a rich data set of household consumption of grain products, combined with data on the nutritional content of the products. We estimate behavioral parameters, which are used to simulate the impact on the average household of various tax reforms, entailing either a subsidy on commodities rich in fiber or a subsidy of the fiber density in grain products. Our results suggest that to direct the fiber intake of the average household towards nutritional recommendations, reforms with a substantial impact on consumer prices are required. Our results also imply that subsidizing the fiber density is more cost-efficient than reducing the VAT on fiber-rich commodities. Regardless of the type of subsidy implemented, the increase in the fiber intake is accompanied by increases in nutrients that are often overconsumed, namely fat, saturated fat, salt, sugar and added sugar. Funding the subsidies by taxing these nutrients, or less healthy commodities, counteracts such developments.

Keywords: consumer economics; food; health; taxation

JEL classification: D12; H23; I1

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1. Introduction

In this paper, we analyze the effects of tax reforms aimed at directing the fiber intake towards nutritional recommendations published by public authorities.

Over the last few decades, technological change has contributed to advances in both food production and transportation, leading to more cost-efficient food production and greater availability of processed and pre-prepared foods. As a result, welfare has been enhanced by falling relative prices of food. On the downside, the modern diet, combined with a more sedentary lifestyle, has proven to be an important factor in a number of serious illnesses, including some types of cancer, cardiovascular disease, diabetes, osteoporosis, and dental caries, as well as overweight and obesity – both major risk factors of many of the diseases mentioned. For instance, cancer and cardiovascular disease account for almost two thirds of the total disease burden in Europe, and poor nutrition is estimated to cause about one third of cancer deaths and one third of deaths from cardiovascular disease (WHO, 2004).

The negative health effects caused by modern food consumption also impose considerable burdens on healthcare budgets and, hence, on taxpayers. In the U.S., direct costs on healthcare from poor nutrition and insufficient exercise account for 7 percent of personal healthcare expenditures (Kenkel and Manning, 1999). In Germany, diet-related diseases have been estimated to account for 30 percent of total costs of healthcare, including both direct and indirect costs (Kohlmeier et al., 1993). In Sweden, obesity and overweight have been estimated to account for direct costs on the national healthcare system of SEK 3.6 billion (Persson et al., 2004) and indirect costs of SEK 12.4 billion (Persson and Ödegaard, 2005). If current trends prevail, diet-related costs will increase even further. The externalities

imposed on taxpayers could justify government intervention aimed at encouraging healthier food consumption.

Another potential justification for government intervention is paternalism. Obesity and overweight may result from self-control problems. Individuals who suffer from self-control problems are too prone to immediate gratification. If they do not commit themselves to behaving fully rationally, their immediate actions impose externalities on their future selves (in this case, immediate overconsumption of unhealthy food, at the expense of their future health).¹

Increasing the intake of dietary fiber is vital to achieve healthier food consumption, and thereby create external benefits for taxpayers. If there is a prevalence of self-control problems, increased fiber intake would also result in external benefits for the future selves of individuals suffering from self-control problems. A high intake of dietary fiber has many health-promoting benefits, such as helping to maintain a healthy body weight (Burton-Freeman, 2000, Liu et al., 2003), and controlling and preventing heart diseases (Liu et al., 1999, Mann, 2002), diabetes (Brand-Miller et al., 2003, Schulze et al., 2004, Willet et al., 2002), and colorectal cancer (Schatzkin et al., 2007). Because of the positive health benefits of a fiber rich diet, the Swedish National Food Administration (SLV) recommends the average Swedish consumer to greatly increase his/her fiber intake. The average woman is recommended to increase her intake by a minimum of 56 percent, and the average man by at least 38 percent.²

¹ For a comprehensive review of, among other things, externalities that could justify policy interventions to improve dietary quality, see Strnad (2004).

² The average woman consumes 112 grams of dietary fiber per week, and the average man 126 grams (Becker and Pearson, 2002). Recommended weekly levels are 175–245 grams of dietary fiber for both men and women (SNR, 1997).

The most important sources of dietary fiber are grain products, fruit, and vegetables.³ Grain products are also the food group that contributes most to our daily energy intake,⁴ as well as perhaps the group with the greatest variety of food products, in terms of health status of the food.⁵ In this study, therefore, we will focus on the effects of tax reforms on grain consumption.

The nutritional recommendations above provide us with the overall policy objective of increasing the fiber intake from grain consumption by a minimum of 38 percent.⁶ To translate this into recommendations for grain product consumption, SLV recommends that the average person (a) doubles her overall intake of bread and breakfast cereals, while (b) ensuring that half of the bread and breakfast cereal consumption carries the healthy “Keyhole” label certified by the SLV (SNÖ, 2003).⁷

³ Due to a lack of available data on fruit and vegetables, analysis in this study is limited to fiber consumption from grain products.

⁴ According to statistics from the Swedish Board of Agriculture, grain product consumption constitutes around a third of the total daily energy intake of the average Swedish consumer. In 2003, grain products represented 18 percent of total food expenditures, while food expenditures themselves made up 12 percent of total household expenditures (Household Budget Survey 2003, Statistics Sweden).

⁵ Wholegrain products are considered part of a healthy diet, whereas white, highly refined grain products are often classified as “empty calories” – food that is energy dense but at the same time low in nutritional value.

⁶ It is worth stressing that the recommended increase in fiber intake is general and includes all food groups, i.e., it is not specific to grain consumption. However, by assuming that the increase in fiber intake should be proportional for all food groups, we use the general recommendations on increased fiber intake as the policy objective for the fiber intake from grain products. To simplify, we also assume that the recommended minimum increase in fiber intake for the average man (38 percent) holds for the average consumer, regardless of gender.

⁷ Breakfast cereals fulfilling the following criteria are allowed to carry the Keyhole symbol (certified by SLV): fat: max. 7g/100g, sugar: max. 13g/100g, sodium: max. 500mg/100g, and fiber: min 1.9g/100 kcal. For soft bread, the certification criteria are: fat: max. 7g/100g, sugar: max. 10g/100g, sodium: max. 600mg/100g, and fiber: min 1.9g/100 kcal. And for crisp bread, the criteria are as follows: fat: max. 8g/100g, sodium: max. 600mg/100g, and fiber: min 1.9g/100 kcal.

While aiming to increase fiber intake, it is however desirable to avoid increases in several other nutrients. Average fat consumption in Sweden amounts to 33–35 percent of total energy consumed, exceeding the recommended 30 percent of daily intake. This is mainly due to a relatively high intake of saturated fat (Becker and Pearson, 2002, and SNR, 1997). The average consumption of salt, excluding added table salt, is more than 40 percent above recommended levels for women and almost 80 percent above recommended levels for men.⁸ For added sugar, the intake of the average Swedish consumer is right at the recommended level (Becker and Pearson, 2002, and SNR, 2005).

For the analysis, we estimate a demand system for grain products based on two micro data sets: household expenditure data on grain products from GfK Sweden and household expenditure data on soft bread from Statistics Sweden. The parameters estimated in the demand system are used to simulate the results of tax reforms aimed at directing grain consumption towards the policy objectives above. Taxes or subsidies on both the commodity and nutrient level are considered: we simulate the results from reforms entailing subsidies of Keyhole labeled products, as well as reforms entailing a subsidy of the fiber density of the product. We also simulate the results of revenue-neutral reforms, where these subsidies are funded by commodity taxes on goods, or excise duties on the nutrients that are often overconsumed in the Western world.

There is a growing amount of theoretical research on the effects of economic policy instruments designed to improve health (see e.g., O'Donoghue and Rabin, 2003, 2006, and Aronsson and Thunström, 2006). This literature is mainly concerned with paternalistic arguments for government intervention. O'Donoghue and Rabin (2003, 2006) suggest that a commodity tax on unhealthy food is the optimal policy

⁸ However, it is difficult for consumers to avoid overconsumption of salt, since most food products in Sweden contain high levels of salt (SNÖ, 2003).

instrument if there are individuals in the population suffering from self-control problems. O'Donoghue and Rabin (2006) also demonstrate that a low prevalence of self-control problems in the population could still yield large optimal taxes. Aronsson and Thunström (2006) use a general equilibrium model to show that a commodity tax may be welfare increasing, but that a subsidy of health capital is the optimal policy instrument, provided there is a prevalence of self-control problems.

Empirical research on the subject is, however, limited. Jensen and Smed (2007) conclude that it is less costly to achieve an increase in fiber intake by subsidizing the fiber content directly, compared to subsidizing products rich in fiber. They find that subsidies of fiber, or products rich in fiber, lead to unwanted increases in the intake of less healthy nutrients, however. Chouinard et al. (2007) analyze the effect of imposing ad valorem taxes on the fat percentage in milk products and conclude that these taxes have small effects on the intake of fat. Finally, Kuchler et al. (2005) find that ad valorem taxes on salty snack foods ranging from 0.4 – 30 percent would have minor effects on consumer behavior and dietary quality.

Small taxes on unhealthy foods, such as soft drinks, snacks, or junk food, have been imposed in Australia, Canada, Finland, Norway, and some states of the U.S., for instance. However, these taxes are generally aimed at generating public revenues rather than affecting consumer behavior (Jacobson and Brownell, 2000). The fact that some countries have already imposed differentiated VAT rates, based on the health status of foods, further increases the importance of empirical research on the effects of such policy measures.

To the best of our knowledge, this is the first study analyzing the effects of policy instruments that are designed to direct consumption towards specific nutritional recommendations. This paper, therefore, provides unique and valuable insights into

the impact of tax schemes that could be used to improve the quality of the modern diet, or even attain nutritional recommendations.

The outline of the paper is as follows. In Sections 2 and 3, we present the modeling framework and data used to estimate the demand system for grain products. Section 4 contains the estimation results. In Section 5, the simulations are described and Section 6 contains the simulation results. Finally, Section 7 provides a summary and conclusions.

2. Modeling Framework

We believe that the decision process can be illustrated by Figure 1, where households allocate expenditures for grain products in multiple steps. At the highest level in the decision process, the household allocates its (total) resources for grain expenditures between three broad product categories: pre-prepared foods, ready meals, and staple goods for cooking. When the household has determined the expenditures for each category, it decides how to allocate these expenditures between the product groups within each category.

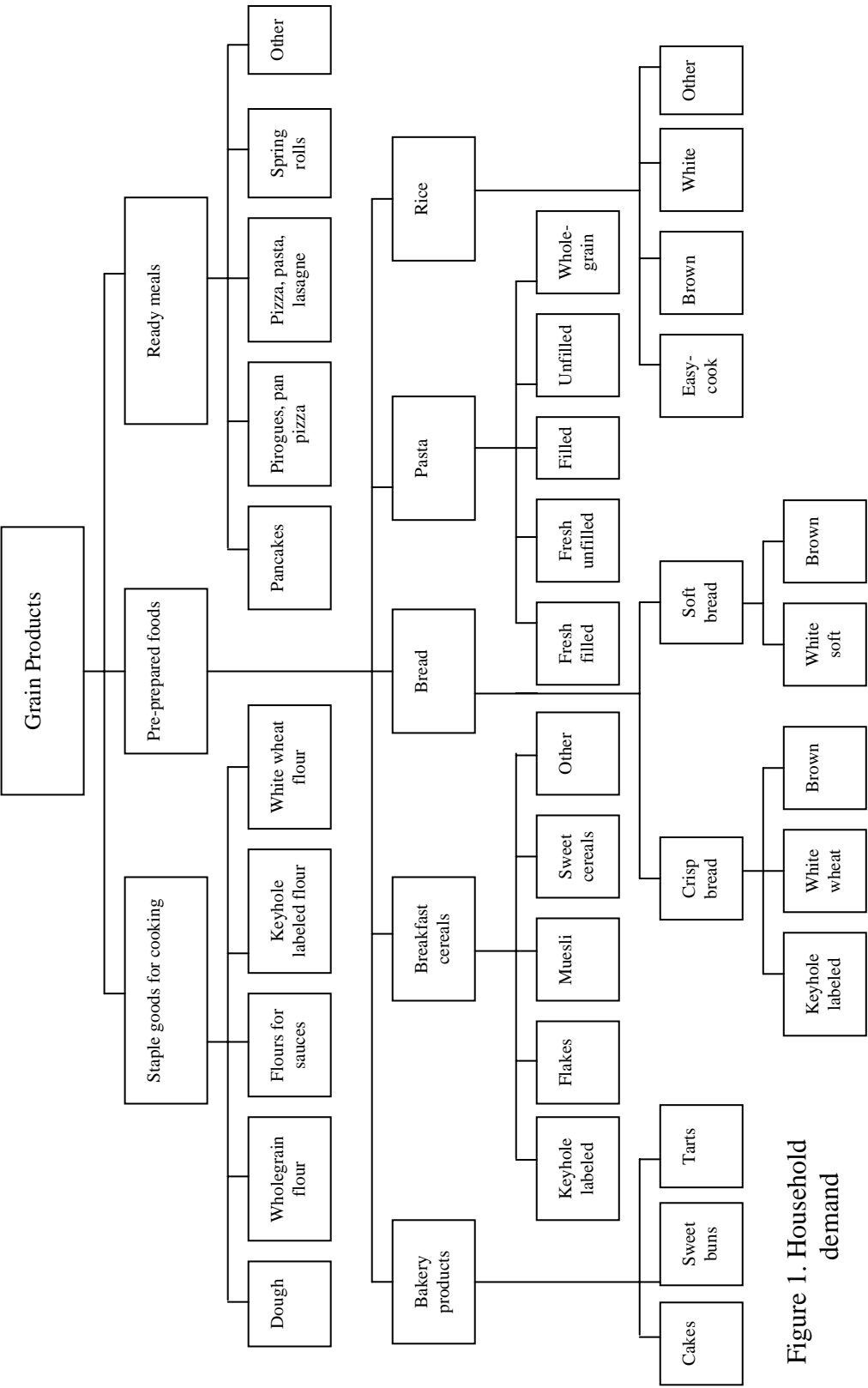


Figure 1. Household demand

2.1 Estimating the demand system

To model demand for grain products, we use the microeconomic data sets described in Section 3 below and the multi-stage allocation process shown in Figure 1. However, we are unable to observe households' total consumption of grain products as some are consumed outside the home (e.g., in restaurants and schools). The relative intake of different grain products is likely to be well reflected in the data set, however, suggesting that a demand system based on budget shares is preferable to one based on quantities or expenditures for the goods.

Further, consumer demand patterns typically found in micro-data sets vary considerably across households with different household characteristics and levels of income. As indicated in Banks et al. (1997), expenditures on some goods are non-linear in total expenditure (or income), while some are linear.

A flexible functional form of consumer preferences, based on budget shares and with the capacity to handle non-linear expenditure effects, is the quadratic extension (Banks et al. 1997) to Deaton and Muellbauer's (1980a) almost ideal demand system (AIDS). We therefore use the quadratic AIDS (QAIDS) model as our basic model specification. We take into account the differences in consumption patterns between household categories by adding intercept and slope parameters in the budget share equations of the demand system. As we cannot observe the households' consumption of other goods, we have to assume that household preferences are weakly separable in grain consumption and other goods. To reduce the number of estimated parameters, we also assume that household preferences are weakly separable into ready meals, staple goods for cooking, and pre-prepared

foods.⁹ The full decision process and the separability assumptions that follow from this process are shown in Figure 1.

We therefore estimate a demand system where the allocation decision is made in several steps. Preferences are characterized in such a way that household h makes decisions on how much grain products to consume, conditional on various household characteristics, \mathbf{d} . Household h 's budget share for good k , s_k^h , in the first allocation stage (i.e., the allocation of resources for staple goods for cooking, pre-prepared foods, and ready meals) then takes the form

$$s_k^h = \alpha_k(\mathbf{d}^h) + \sum_l \gamma_{kl} \ln p_l^h + \beta_k(\mathbf{d}^h) \times \ln \left[x^h / a^h(p, \mathbf{d}) \right] + \left(\delta_k(\mathbf{d}^h) / b^h(p, \mathbf{d}) \right) \times \left(\ln \left[x^h / a^h(p, \mathbf{d}) \right] \right)^2 \quad k = 1, \dots, n \quad (1)$$

where p_l^h is the price of good l , x^h is household h 's total expenditure on the $k = 1, \dots, n$ grain product groups, \mathbf{d} is a vector of household characteristics, and $\ln a^h(\cdot)$ and $\ln b^h(\cdot)$ are defined by

$$\ln a^h(p, \mathbf{d}) = \sum_l \alpha_l(\mathbf{d}^h) \ln p_l^h + \frac{1}{2} \sum_k \sum_l \gamma_{kl} \ln p_k^h \ln p_l^h \quad (2)$$

$$\ln b^h(p, \mathbf{d}) = \sum_{k=1} \beta_k(\mathbf{d}^h) \ln p_k^h \quad (3)$$

⁹ Although the separability assumption imposes restrictions on the substitution possibilities between goods in different subgroups, there is no restriction on the substitution possibility between the goods within a subgroup. As we use very disaggregated data in this study, with a healthy alternative within most subgroups, we believe that we are able to estimate the main substitution effects with this model. Separability does not imply that price changes of goods in different groups do not affect each other, but merely that such effects are channeled through the group expenditures, via changes in group prices and expenditure levels at the upper allocations stage (Deaton and Muellbauer, 1980b, pp 127-133).

The household characteristics included in the \mathbf{d} vector of dummy variables are as follows: a single woman with children, single man with and without children, two adults without children, two adults with one child, two adults with two children, two adults with three or more children, three or more adults, part-time worker, student, and pensioner. The reference household consists of a full-time working single woman without children. A person is considered a child up to the age of 16.

The demand system for the second stage of expenditure allocation has the same functional form as (1), and can be written as

$$s_{(k)i}^h = \alpha_{(k)i}(\mathbf{d}^h) + \sum_j \gamma_{(k)ij} \ln p_{(k)j}^h + \beta_{(k)i}(\mathbf{d}^h) \times \ln \left[x_k^h / a_k^h(p, \mathbf{d}) \right] + \left(\delta_{(k)i}(\mathbf{d}^h) / b_k^h(p) \right) \times \left(\ln \left[x_k^h / a_k^h(p, \mathbf{d}) \right] \right)^2 \quad i = 1, \dots, m \quad (4)$$

where $s_{(k)i}^h$ is household h 's budget share for good i within group k , $p_{(k)j}$ is the price of good j in group k , and x_k^h are the total expenditures that household h has allocated to the goods in group k in the first stage allocation problem. This procedure extends in a natural way to similar sub-demand systems when we have three-stage and four-stage allocation of expenditures on grain products.

2.2 Econometric Considerations

Many households in the sample did not purchase some of the goods in 2003. For example, for fresh filled and fresh unfilled pasta the occurrence of zero expenditure is as high as 92 and 83 percent. The model traditionally used to account for

censoring in commodity demand is the Tobit model (Tobin, 1958, and Amemiya, 1974). However, the underlying assumption in such models¹⁰ is that the same stochastic process determines both the value of continuous observations of the dependent variable and the discrete switch at zero. That is, a zero realization for the dependent variable represents a corner solution. This clearly restricts other possible determinants of the zero observations, such as potential infrequencies of purchases or misreporting in commodity demand. Such restrictions have been recognized in the past by, for example, Deaton and Irish (1984) and Blundell and Meghir (1987).

Whether the zeros are a result of infrequencies of purchases or of non-consumption is difficult to say. To allow for infrequencies of purchases, Blundell and Meghir (1987) presented a bivariate alternative to the Tobit model with separate processes determining the censoring rule and the continuous observations. It is also reasonable to assume that there are separate processes determining the zero-one decision of buying a good and the decision of how many units to actually buy. Therefore, to obtain consistent parameter estimates we follow Heckman's (1979) two-step procedure and estimate separate probit and truncated regression models for each commodity group.

Following Blundell et al. (1993), we simplify the simulations by specifying $\ln a^h(p, d)$ as the household specific Stone price index, $\ln P^h = \sum_k s_k^h \ln p_k$, and setting the price aggregator, $\ln b^h(p, d)$, equal to one. The estimated demand system for household h can therefore be written as

¹⁰ I.e., the Tobit1 model, Amemiya (1984).

$$\begin{aligned}
s_k^h = & \alpha_k(\mathbf{d}^h) + \sum_l \gamma_{kl} \ln p_l^h + \beta_k(\mathbf{d}^h) \times \ln[x^h / P^h] & k = 1, \dots, n \\
& + \delta_k(\mathbf{d}^h) \times \left(\ln[x^h / P^h] \right)^2 + \varphi_k \hat{\lambda}_k^h + \varepsilon_k^h & h = 1, \dots, r
\end{aligned} \tag{5}$$

where ε_k^h is an error term reflecting unobserved taste variation and r denotes the subsample for which $s_k^h > 0$. In addition, $\hat{\lambda}_k^h = \phi(\hat{\psi}_k \mathbf{z}_k^h) / \Phi(\hat{\psi}_k \mathbf{z}_k^h)$ is the estimated inverse Mills ratio, where $\phi(\cdot)$ and $\Phi(\cdot)$ are the probability density and cumulative distribution functions of the standard normal distribution, with $\hat{\psi}_k$ estimated in a first step from a univariate probit model for group k (see e.g., Leung and Yu, 1996). The explanatory variables included in \mathbf{z}_k are the prices of the products in equation k , the household income, and the same set of dummy variables as those contained in the \mathbf{d} vector. Although the notation in equation (4) refers to the demand for the k goods in the first allocation stage, the same procedure has been used in the estimation of all sub-demand systems, see Figure 1.

The expenditure system has a set of within-equation and cross-equation restrictions that we impose. These are homogeneity, which gives rise only to within-equation restrictions, and symmetry, which gives rise to cross-equation restrictions. Homogeneity can thus be imposed in a first stage by estimating single equations. Since the number of observations will differ for different goods after the selection of $s_k^h > 0$, we use a minimum distance estimator (see Ferguson, 1958) to impose the cross-equation restrictions in a second stage. If estimating the regression system simultaneously, we would lose information, as only households with $s_k^h > 0, \forall k$ would be included in the regression.

Let $\hat{\mu}$ be a $q \times 1$ vector of unrestricted parameters, and let θ be a vector of symmetry-restricted parameters of dimension $p \times 1$. Then under the null $\theta = g(\hat{\mu})$, where g is a known function and $p \leq q$, the symmetry-restricted parameter estimates can be obtained by minimizing

$$\Psi(\theta) = [\hat{\mu} - \theta]' \begin{bmatrix} \hat{\Sigma}_{\mu_1} & 0 & 0 \\ 0 & \ddots & 0 \\ 0 & 0 & \hat{\Sigma}_{\mu_n} \end{bmatrix}^{-1} [\hat{\mu} - \theta] \quad (6)$$

where $\hat{\Sigma}_{\mu_1}$ is an estimate of the covariance matrix of $\hat{\mu}_1$ and the subscript $1, \dots, n$ refers the equation for a specific good within the demand system.¹¹ The minimized value of $\Psi(\theta)$ follows a chi-square distribution with degrees of freedom equal to the number of restrictions. The consistency of the minimum distance estimator simply requires that the restrictions are correct and that $\hat{\mu}$ is a consistent estimator. For the linear case the restrictions simplify to $\theta = K\mu$, where K is a $q \times p$ matrix. Instead of specifying a particular form of the heteroscedasticity, we employ White's (1980) approach to calculate the standard errors. In practice, we apply a minimum distance estimator for each separate demand system within the total demand system.

3. Data

To perform the analysis, we use three data sources. To estimate the demand system for grain products, we use market research data from GfK Sweden and household expenditure data (HUT) on bread purchases from Statistics Sweden. We match

¹¹ The minimum distance estimator is only applied to the price parameters, meaning that the other parameters in the demand system will not be affected.

household purchases with their product contents by using nutritional information from the SLV nutrition database.

The GfK data are based on weekly diary recordings of grain product purchases. To reduce the prevalence of non-purchases (zeros) in the sample, we aggregate the data to a yearly level.¹² The data contain information on annual retail purchases of bakery products¹³, bread, breakfast cereals, frozen and fresh ready-to-eat food, pasta, rice, and flours. The information on products purchased by GfK households is detailed and includes type, price, and size of the products bought. An exception is soft bread, for which households are only requested to state whether they have purchased the product (i.e., “soft bread”), omitting all other product-specific information, with the exception of total expenditures. To gain more information on the type of bread purchased, we therefore use 1996 household expenditure data (HUT) from Statistics Sweden, which provide information on the amounts of types of bread (white or brown) purchased, as well as a price index for bread prices.

To be able to aggregate the purchases to a yearly level, we need to observe the households’ purchases for a full year. The GfK household panel included 1336 households over the whole of 2003 and these are hence contained in the sample used for the analysis. The sample of households is satisfactorily representative of the population, even though pensioners are overrepresented. The sample of households in the data from Statistics Sweden comprises 1104 households.

¹² Simulation results in Leung and Yu (1996) show that the parameter bias and parameter squared error increase as the degree of censoring increases (i.e., the smaller the proportions of uncensored observations).

¹³ Note that the bakery products category does not contain bread.

3.1 Consumption patterns of the average household

Table 3.1 shows descriptive statistics on the budget shares for the sample. Pre-prepared foods is the dominant group regarding grain consumption, with the average household devoting more than 80 percent of its total grain expenditures to this group, while the rest of the grain budget is fairly evenly allocated between ready meals and staple goods for cooking. Bread and breakfast cereals are, in turn, the dominant groups within pre-prepared foods, with 66 percent of total pre-prepared food expenditures for the average household being devoted to bread and 17 percent to breakfast cereals. Within the bread group, households on average allocate 88 percent of their expenditures to soft bread; and within soft bread, the average household allocates its expenditures fairly evenly between brown and white bread. Since we are not able to single out Keyhole labeled soft bread, we will use the soft brown bread as a proxy for Keyhole labeled soft bread in the analysis. It is noteworthy that within the crisp bread group Keyhole labeled crisp bread is clearly dominant. As for breakfast cereals, most of the expenditures in this group are allocated to flakes and muesli.¹⁴

¹⁴ It should be noted that the selection of breakfast cereal products into the Keyhole labeled group is based on the 2005 criteria for Keyhole certification (LIVSFS, 2005:9), whereas the expenditure data are from 2003. The 2005 criteria are stricter than those of 2003 (required minimum levels of fat, salt, and sugar are lower, whereas required levels of dietary fiber are higher). For many products, there were no maximum levels of salt and sugar in 2003 (SLVFS, 1989:2). It should therefore be expected that some of the products found in the muesli group did fulfill the 2003 Keyhole criteria, and that today product contents have been revised to fulfill the 2005 criteria. The budget share for Keyhole labeled breakfast cereals is therefore likely to be understated. On the other hand, using soft brown bread as a proxy for Keyhole labeled soft bread in the analysis means that the proportion of Keyhole labeled soft bread is likely to be overstated, since not all soft brown bread is Keyhole labeled.

Table 3.1. Budget shares of the average household, at different allocation steps

Group	Product	Budget share	Group	Product	Budget share
<i>First allocation stage</i>			<i>Third allocation stage</i>		
<i>Purchases of grain products</i>	Pre-prepared foods	0.839	<i>Bakery products</i>	Cakes	0.734
	Staple goods for cooking	0.079		Sweet buns	0.176
	Ready meals	0.082		Tarts	0.090
	<i>Sum</i>	<i>1.000</i>		<i>Sum</i>	<i>1.000</i>
<i>Second allocation stage</i>					
<i>Pre-prepared foods</i>	Bakery products	0.024	<i>Breakfast Cereals</i>	Flakes	0.411
	Bread	0.657		Muesli	0.362
	Breakfast cereals	0.173		Keyhole labeled	0.035
	Pasta	0.079		Sweet cereals	0.141
	Rice	0.067		Others	0.050
	<i>Sum</i>	<i>1.000</i>		<i>Sum</i>	<i>1.000</i>
<i>Staple goods for cooking</i>	Wholegrain flour	0.085	<i>Pasta</i>	Unfilled	0.853
	Flour for sauces	0.133		Fresh unfilled	0.084
	Keyhole labeled flour	0.070		Wholegrain	0.010
	White wheat flour	0.679		Fresh filled	0.030
	Dough	0.033		Filled	0.024
	<i>Sum</i>	<i>1.000</i>		<i>Sum</i>	<i>1.000</i>
<i>Ready meals</i>	Pancakes	0.073	<i>Rice</i>	Easy-cook	0.078
	Pirogues ^a	0.236		Brown	0.066
	Pizza ^b	0.556		White	0.681
	Spring rolls	0.076		Others	0.175
	Others	0.060		<i>Sum</i>	<i>1.000</i>
	<i>Sum</i>	<i>1.000</i>	<i>Bread</i>	Crisp bread	0.119
				Soft bread	0.881
				<i>Sum</i>	<i>1.000</i>

Table 3.1 continued:

Group	Product <i>Fourth allocation stage</i>	Budget share
<i>Crisp bread</i>	Keyhole labeled	0.786
	White wheat	0.193
	Brown	0.021
	<i>Sum</i>	<i>1.000</i>
<i>Soft Bread</i>	Brown	0.483
	White	0.517
	<i>Sum</i>	<i>1.000</i>

Note: ^a The pirogues group also includes pan pizza. ^b The pizza group also includes pasta and lasagne.

3.2 Product characteristics

Food products purchased by GfK and HUT households are matched with their product contents using the information on nutritional values in the SLV nutrient database. The level of detail in the GfK data allows us to match a product of a specific brand (here called “brand product”) with its product content. The brand products are thereafter divided into somewhat more aggregated products (for example, all dry, white wheat pasta of different brands is aggregated into one product, unfilled pasta). The product content is the weighted average of the contents of the brand products, where the shares of purchases of different brands are used as weights. The nutrient contents matched with the products are energy density (kilojoules per 100 grams of product), density of fat, saturated fat, sugar, added sugar, salt, and fiber, all measured in grams per 100 grams of product. For

convenience, we will refer to fat, saturated fat, sugar, added sugar, and salt as the “unhealthy” nutrients, as the average household is likely to overconsume these nutrients. For underweight individuals, however, an increased intake of these nutrients will be health-enhancing, with salt perhaps an exception. Descriptive statistics of the product contents are given in Table 3.2.

Table 3.2. Average nutritional content in product groups, per 100 grams of product

	KJ	Total fat	Saturated fat	Sugar	Added sugar	Salt	Fiber
Bakery products							
Cakes	1631.71	24.29	6.33	27.89	25.35	164.26	2.25
Sweet buns	1633.77	20.12	8.23	11.64	6.32	267.47	2.12
Tarts	1084.16	13.62	6.21	17.23	13.45	133.76	1.60
Bread							
<i>Crisp bread</i>							
Keyhole labeled	1359.82	2.61	0.38	1.73	0.43	470.20	14.29
White wheat	1636.54	7.41	1.79	4.52	0.42	417.19	5.38
Brown	1425.18	3.98	0.99	3.56	0.29	540.53	11.78
<i>Soft bread</i>							
Brown	1025.82	3.07	0.55	6.03	0.31	358.77	6.47
White	1160.12	4.11	0.81	4.07	0.21	404.35	3.62
Breakfast cereals							
Flakes	1568.93	1.95	0.35	13.46	10.12	895.30	4.23
Keyhole labeled	1448.28	3.67	0.51	2.65	1.73	199.00	9.88
Muesli	1578.77	9.26	3.41	23.37	15.14	256.96	10.80
Sweet cereals	1614.75	1.26	0.25	38.39	28.86	467.08	2.56
Others	1567.01	4.30	1.24	21.44	16.60	368.64	6.21
Flours & dough							
Wholegrain flour	1417.67	2.33	0.28	2.74	0.43	2.64	4.62
Flour for sauces	1407.06	0.69	0.09	1.13	0.51	4.48	3.03
Keyhole labeled flour	1344.52	3.33	0.48	1.24	0.65	3.41	10.89
White wheat flour	1504.68	1.88	0.26	1.53	0.26	0.80	3.60
Dough	2340.20	39.51	17.08	1.10	0.12	309.44	1.60

Table 3.2 continued:

Pasta							
Fresh filled	708.24	9.15	4.07	0.98	0.14	522.37	0.83
Fresh unfilled	877.06	1.61	0.42	1.01	0.10	297.63	1.78
Filled	767.16	9.90	4.38	1.03	0.18	569.30	1.03
Unfilled	528.50	0.50	0.05	0.20	0.10	1.00	1.12
Wholegrain	473.30	0.52	0.06	0.17	0.10	0.10	3.04
Ready meals							
Pancakes	807.95	8.81	3.73	4.37	0.01	331.15	0.77
Pirogues, pan pizza	1541.16	23.43	10.11	1.82	0.31	533.81	1.36
Pizza, pasta, lasagne	910.06	9.73	4.14	2.20	0.20	472.06	1.43
Spring rolls	896.20	10.80	2.94	2.80	0.20	510.00	1.20
Others	1024.73	13.26	5.88	2.07	0.25	462.82	1.36
Rice							
Easy-cook	490.91	0.30	0.07	0.32	0.28	270.07	0.50
Brown	443.54	0.70	0.18	0.49	0.32	2.62	1.12
White	515.25	0.34	0.10	0.15	0.15	307.07	0.48
Others	520.56	0.29	0.10	0.09	0.11	171.77	0.36

As expected, bakery products have the highest energy density of all product groups in the data, but the individual product with the highest energy density turns out to be white crisp wheat bread. The highest fat content is found in dough (almost 40 grams per 100 grams), which is mainly due to the fact that it consists almost exclusively of puff paste. Also cakes, sweet buns, and pirogues and pan pizzas contain high proportions of fat (24, 20, and 23 grams per 100 grams, respectively). The product with the highest proportion of fiber is Keyhole labeled crisp bread, with more than 14 grams of fiber per 100 grams of product.¹⁵

¹⁵ In Table 3.2, it is important to note that the product crisp brown bread fulfills the criteria for Keyhole labeling on *average*. However, none of the individual products in this group fulfills these criteria and, hence, they are not included in the Keyhole labeled group.

3.3 Dietary quality of the average household

We measure dietary quality by the density of the nutrients in the household diet, i.e., the grams of nutrients per 100 grams of product. Descriptive statistics of dietary quality for the average household are given in column 1 of Table 6.1. The density of unhealthy nutrients such as fat and sugar in the average grain diet seems to be relatively low. Table 6.1 also shows that the proportion of Keyhole labeled bread and breakfast cereals, of total bread and breakfast cereals purchased by the average household, amounts to 47 percent, whereas the proportion of bakery products and ready meals of total grain purchases amounts to 3 percent.

4. Estimation results

F -tests indicate that the estimates of the parameters of the β and δ functions, in the original specification, are not significantly different from zero. We have therefore reduced the number of estimated parameters in the final specification of the model and excluded the household-specific parameters from these functions. The final estimation results show the importance of quadratic terms in real expenditures as well as the importance of controlling for non-consumption. In 35 out of 42 cases (and for all of the equations at the lowest level of aggregation, except for white wheat flour and cakes) the estimated parameters for the non-linear expenditure variable are significantly different from zero, at a 5 percent significance level. Using the same significance level, we find that 22 percent of the estimated parameters, controlling for censoring and non-consumption (i.e., the variable related to the inverse Mills ratio), are significantly different from zero.

Likelihood ratio tests for homogeneity generally suggest that this restriction cannot be rejected. Chi-square tests indicate that the symmetry restrictions are rejected for

only two of the nine estimated demand systems, at a 5 percent significance level. The symmetry restrictions are rejected for the sub-demand systems for pasta and bread, with P -values 0.02 and 0.00, respectively. The lowest P -value for the chi-square test for symmetry in the other sub-demand systems is 0.18. The adjusted R -square is generally high and lies in the range 0.2 to 0.6. Overall, the model fit is found to be good.

The estimation results are, however, easiest summarized by elasticities. Compensated and uncompensated own price elasticities, as well as expenditure elasticities, are shown in Table 4.1. The formulas to calculate the own price and expenditure elasticities are given in Appendix B.

Table 4.1. Compensated and uncompensated own price elasticities and expenditure elasticities

	Uncompensated price elasticity	Compensated price elasticity	Expenditure elasticity
Bakery products			
Cakes	-0.56	-0.53	0.46
Sweet buns	-0.64	-0.63	0.29
Tarts	-0.58	-0.57	0.19
Bread			
<i>Crisp bread</i>			
Keyhole labeled	-0.80	-0.77	0.27
White wheat	-1.27	-1.26	0.18
Brown	-0.72	-0.72	0.15
<i>Soft bread</i>			
Brown	-0.99	-0.83	0.64
White	-0.95	-0.81	0.58
Breakfast cereals			
Flakes	-0.71	-0.62	1.01
Keyhole labeled	-0.70	-0.68	0.60
Muesli	-0.73	-0.63	1.16
Sweet cereals	-0.71	-0.65	0.83
Others	-1.56	-1.53	0.81

Table 4.1 continued:

Flours & dough			
Wholegrain flours	-0.84	-0.82	1.12
Flours for sauces	-0.49	-0.47	0.68
Keyhole labeled flours	-0.79	-0.77	0.93
White wheat flours	-0.95	-0.87	1.45
Dough	-0.37	-0.35	0.83
Pasta			
Fresh filled pasta	-0.43	-0.42	0.65
Fresh unfilled pasta	-0.74	-0.73	0.60
Filled pasta	-1.50	-1.50	0.13
Unfilled pasta	-0.60	-0.54	1.05
Wholegrain pasta	-0.21	-0.20	0.58
Ready meals			
Pancakes	-0.78	-0.75	0.42
Pirogues	-0.86	-0.81	0.70
Pizzas	-0.70	-0.62	0.69
Spring rolls	-0.89	-0.87	0.38
Others	-0.26	-0.24	0.43
Rice			
Easy-cook	-0.87	-0.85	0.67
Brown	-0.50	-0.49	0.52
White	-0.68	-0.64	0.84
Others	-0.85	-0.84	0.44

As shown by Table 4.1, all compensated own price elasticities are negative, indicating that the negativity condition is fulfilled. The uncompensated own price elasticities range from -0.21 for wholegrain pasta to -1.56 for “other” breakfast cereals. With the exception of filled pasta, pasta products generally show the lowest price sensitivity. Another group of products characterized by relatively low own price elasticities (in absolute values) are bakery products. Furthermore, the results indicate that white crisp wheat bread is the product with the highest price sensitivity within the bread group. For Keyhole labeled and brown crisp bread, the price sensitivity is lower, with estimated own price elasticities of -0.8 and -0.7, respectively. The fact that the price sensitivity for white crisp wheat bread is higher

than that for other crisp bread products might be a result of this type of crisp bread being a closer substitute to soft bread. For the products within breakfast cereals, the own price elasticities are estimated to be around -0.7 (“others” being the exception), and own price elasticities for the products within the rice group vary between -0.5 and -0.9. The products within ready meals generally have an own price elasticity of around -0.8. We also calculated cross-price elasticities and, as expected, these are generally much smaller in absolute value than the own price elasticities reported here.

The expenditure elasticities are also of the expected sign, ranging from 0.13 and 0.15 for filled pasta and white crisp wheat bread to 1.16 and 1.45 for muesli and white wheat flour.

The own price elasticities in Table 4.1 are in line with elasticities reported by previous studies (e.g., Chouinard et al., 2007, and Kuchler et al., 2005).

5. Simulations

The empirical model from Section 3.1 is used to illustrate responses of households to non-marginal changes of the value added tax (VAT) on different food products, as well as to excise duties on nutrients in the grain products. The type of model used here is particularly useful for such analyses. A non-marginal tax change that has a sizeable impact on prices will affect households’ real income. A demand system of the type used here takes this income effect into account. In addition, the model employed includes non-linear income effects, which may be important when large tax changes are considered. In addition, the demand system handles substitution effects, which might be large as a result of the changes in tax rates.

5.1 Policy reforms

In Sweden, the VAT on food is 10.71 percent of the consumer price (or, equivalently, 12 percent of the producer price). Our baseline scenario, therefore, is a 10.71 percent VAT rate on the consumer price of all grain products. We start off by simulating the effects of a reform that is relatively easy to communicate and implement:

(i) removal of VAT on Keyhole labeled bread and breakfast cereals, while keeping the VAT on all other grain products at the initial 10.71 percent.

This kind of unfunded reform that removes an existing tax on healthy products is commonly suggested in the public debate as a means of encouraging healthier food consumption. We therefore consider this reform a natural starting point for the analysis. As will be shown, this reform has little impact on fiber intake, however. We therefore simulate the effect of a more extensive VAT reform, designed to increase the fiber intake of the average household by the recommended 38 percent:

(ii) a 50 percent subsidy of Keyhole labeled bread and breakfast cereals.

Instead of subsidizing commodities, policymakers might consider subsidizing fiber content. To compare the effects of VAT and fiber subsidy reforms, we therefore also analyze the effects of a corresponding fiber subsidy, designed to increase the fiber intake of the average household by 38 percent:

(iii) a SEK 0.046 subsidy per gram of fiber per kilogram of grain product.

The above reforms turn out to yield unwanted side effects, as they tend to increase the intake of what are generally considered unhealthy nutrients. Therefore, we also simulate the results of funded reforms, i.e., policy packages with the above subsidies, funded by taxes on unhealthy commodities and nutrients, respectively.¹⁶ The aim of these simulations is to study the effects on the intake of different nutrients from combined taxes, on healthy and unhealthy commodities/nutrients, and the efficiency of different funding methods.

5.2 Simulation model

The simulation method can be described as follows. The percentage price change on good i in group k is calculated according to the following formula

$$\frac{\Delta p_{(k)i}}{p_{(k)i}^0} = \frac{(t_i^1 + \tau_i^1 + t_i^1 \tau_i^1) - (t_i^0)}{1 + t_i^0} \quad (7)$$

where the superscript denotes the tax regime (0 denotes the baseline tax), t is the VAT rate (on the consumer price) for good i , and τ is the excise duty (or fiber subsidy) on good i . It should be noted that τ shows the excise duty share of the producer price (price exclusive of taxes). The price level for household h for good i in group k after the tax change is then equal to

$$p_{(k)i}^{h1} = \left(1 + \frac{\Delta p_{(k)i}^h}{p_{(k)i}^{h0}} \right) p_{(k)i}^{h0} \quad (8)$$

¹⁶ We also simulated the results of a fiber subsidy reform (a SEK 0.0087 subsidy per gram of fiber per kilogram of grain product) that achieved the same increase in fiber intake as the reform entailing a removal of the VAT on Keyhole labeled bread and breakfast cereals. However, the impact on the grain diet of such a small fiber subsidy reform proved to be minor and is therefore not reported here. It is worth mentioning, however, that the qualitative effects on the diet of the average consumer of the small fiber subsidy reform turned out to be the same as the more extensive fiber reform reported here.

which means that the post-reform Stone price index for group k and household h equals

$$\ln P_k^{h1} = \sum_i s_{(k)i}^h \ln p_{(k)i}^{h1} \quad (9)$$

where, as previously, $s_{(k)i}^h$ is household h 's initial expenditure share on good i in group k . In the simulation we do not allow for possible general equilibrium effects, i.e., we assume that taxes are shifted completely on consumer prices.

Substituting the post-reform Stone price indexes into the demand system representing the first-stage budgeting process gives us the new allocation across the different commodity groups for household h . The new consumption vector is given by

$$\begin{aligned} s_{(k)}^{h1} = & \hat{\alpha}_{(k)} \mathbf{d}^h + \sum_k \hat{\gamma}_{kl} \ln p_k^{h1} + \hat{\beta}_{(k)} \ln [x^{h0} / P^{h1}] \\ & + \hat{\delta}_{(k)} \left(\ln [x^{h0} / P^{h1}] \right)^2 + \hat{\varepsilon}_{(k)}^{h0} \end{aligned} \quad k = 1, \dots, n \quad (10)$$

where a $\hat{}$ denotes an estimate and \mathbf{d}^h is the vector of household characteristics. The superscript 0 indicates the point of reference (baseline). In the simulations we keep nominal expenditure (x) unchanged. The last term in equation (10), $\hat{\varepsilon}_{(k)}^{h0}$, represents unexplained household-specific effects not accounted for in the estimations, and the effect of non-purchase. The latter is assumed to be constant over simulations.

Given the new group shares, according to equation (10), new expenditures on each group will be

$$x_{(k)}^{h1} = s_{(k)}^{h1} x^{h0} \quad k = 1, \dots, n \quad (11)$$

which is substituted into the demand system representing the second stage of the budgeting process. This results in

$$\begin{aligned} s_{(k)i}^{h1} = & \hat{\alpha}_{(k)i} \mathbf{d}^h + \sum_j \hat{\gamma}_{ij} \ln p_{(k)j}^{h1} + \hat{\beta}_{(k)i} \ln [x_{(k)}^{h1} / P_{(k)}^{h1}] \\ & + \hat{\delta}_{(k)i} \left(\ln [x_{(k)}^{h1} / P_{(k)}^{h1}] \right)^2 + \hat{\varepsilon}_{(k)i}^{h0} \end{aligned} \quad i = 1, \dots, m \quad (12)$$

In the case of additional subgroups, or allocation stages, the above procedure is repeated for each allocation stage. From (12) we can define post-reform expenditures x_i^{h1} on good i and the amount V_i^{h1} of good i as

$$x_i^{h1} = s_{(k)i}^{h1} x_k^{h1} \quad (13a)$$

$$V_i^{h1} = x_i^{h1} / p_{(k)i}^{h1} \quad (13b)$$

The change in the intake of nutrient q for household h , ΔN_q^h , can then be calculated by

$$\Delta N_q^h = \sum_i \omega_{iq}^h (V_i^{h1} - V_i^{h0}) \quad (14)$$

where ω_{iq}^h is the content per kilogram of characteristic q (fat, saturated fat, fiber, kilojoules, salt, sugar or added sugar) in product i , for household h .¹⁷

Each household's tax payment on product i , before and after the tax reform, is calculated as

$$VAT^{h0} = \sum_i t_i^0 x_i^{h0} \quad (15a)$$

$$VAT^{h1} = \sum_i t_i^1 x_i^{h1} \quad (15b)$$

$$T^{h1} = \sum_q \sum_i \pi_q \omega_{iq}^h V_i^{h1} \quad (15c)$$

where VAT denotes value added tax payment, and T the excise duties paid on food products. π_q is the excise duty in SEK per gram of characteristic q in each kilogram of grain product.

6. Simulation results

In this section, we report on the results from simulating reforms (i)-(iii) in Section 5.1. To facilitate this, we name reform (i), i.e., the removal of VAT on Keyhole labeled bread and breakfast cereals, “VAT reform (1)”. As already stated, this reform is the easiest to implement and also one commonly put forward in the national debate. The more extensive reforms, (ii) and (iii), i.e., the VAT and fiber subsidy reforms designed to achieve the recommended 38 percent increase in fiber intake by the average household, are named “VAT reform (2)” and “fiber subsidy reform”, respectively.

¹⁷ Note that the content of nutrients of products can differ across households since the calculations of the content are based on the household-specific basket of brand products that make up each product in the demand system.

We begin this section by analyzing the simulated results from the unfunded reforms outlined above, and thereafter analyze the simulated results of reforms funded by taxes on particularly unhealthy commodities and excise duties on particularly unhealthy nutrients.

We analyze how the policy reforms affect the prices of individual products and the overall price level faced by the average household, calculated as the change in the antilog of Stone's price index. We continue by analyzing the impact of the price changes on diets and public revenues, the latter calculated as the relative change in VAT and excise duty payments on grain products by the average household. Simulation results are driven by the combination of own-price, cross-price, and income effects, as well as by the nutritional content of the products.

6.1 Effects of unfunded reforms

Table A.1 in Appendix A shows the impact on prices of grain products of implementing the unfunded reforms. Column 1 shows the price changes resulting from VAT reform (1), and columns 2 and 3 the price changes from VAT reform (2) and its corresponding fiber subsidy reform. Price changes due to the fiber subsidy reform are the least transparent. As shown by column 3 in Table A.1, if the fiber subsidy was implemented, price decreases for some products would be substantial. For instance, the price of Keyhole labeled flour would be 45 percent of the baseline price.¹⁸

¹⁸ Note also that relative price changes are sizeable for white wheat flour due to the excise duty reforms. This result is due to the price of white wheat flour being low at baseline, i.e., it is not a result of white wheat flour being particularly rich in fiber.

Comparing columns 2 and 3 in Table A.2, Appendix A, we find that a VAT reform designed to achieve a 38 percent increase in fiber intake has a greater impact on price level than a fiber subsidy reform that directs the consumption of the average household to the same increase in fiber intake.

Table 6.1 shows the adjustments in diet by the average household, and the resulting relative change in public revenues from grain consumption by the average household as a result of these price changes. Column 1 in Table 6.1 shows the baseline, i.e., the composition of the grain diet of the average household before any reform has been implemented. Columns 2-4 show the results of the respective policy reforms.

Table 6.1. Impact on the average household of simulated policy reforms

	Baseline	Policy reform		
		VAT reform (1)	VAT reform (2)	Fiber subsidy reform
Proportion of Keyhole labeled bread and breakfast cereals	0.47	0.50	0.69	0.51
Proportion of bakery products and ready meals	0.03	0.03	0.03	0.03
Relative change of amounts and intake of nutrients				
Amounts of bread and breakfast		0.03	0.40	0.11
Amounts of bakery products and ready meals		0.01	0.06	-0.04
Fiber		0.04	0.38	0.38
Fat		0.02	0.18	0.26
Saturated fat		0.01	0.13	0.20
Kilojoules		0.02	0.20	0.32
Salt		0.02	0.25	0.09
Sugar		0.02	0.25	0.19
Added sugar		0.01	0.12	0.19
Density of nutrients in the grain diet				
Fiber/100 g grain purchases	3.32	3.37	3.80	3.62
Fat/100 g grain purchases	2.25	2.23	2.17	2.24
Saturated fat/100 g grain purchases	0.55	0.54	0.50	0.52
Kilojoules/100 g grain purchases	936.56	935.59	937.52	988.67
Salt in mg/100 g grain purchases	190.67	190.13	196.05	175.54
Sugars/100 g grain purchases	2.86	2.85	2.87	2.74
Added sugars/100 g grain purchases	1.12	1.10	0.97	1.06
Effects on public revenues				
Average relative change in VAT and excise duty paid in SEK		-0.30	-1.60	-1.29

Note: VAT reform (1) means imposing zero VAT on Keyhole labeled bread and breakfast cereals. VAT reform (2) means introducing a 50 percent subsidy of Keyhole labeled bread

and breakfast cereals. Fiber subsidy reform means implementing a subsidy per gram of fiber, per kilogram of grain product, of SEK 0.046.

As shown by the second column (VAT reform (1)), our results imply that removing the VAT on Keyhole labeled bread and breakfast cereals results in the average household achieving the recommendation that half of bread and breakfast cereal consumption should be Keyhole labeled. However, the increase in amounts of bread and breakfast cereals consumed is small, only 3 percent, which is also shown in the moderate increase in fiber consumption, just 4 percent. This suggests that the average household would be far from achieving the recommended aim of doubling its bread and breakfast cereal consumption (alternatively increasing its fiber intake by a minimum of 38 percent), should this reform be implemented. In addition, our results suggest that the amount of unhealthy grain products consumed would increase (bakery products and ready meals), although by a modest 1 percent, for the average household. The amount of unhealthy nutrients consumed increases by 1-2 percent. The fiber density of the grain diet increases from 3.32 grams per 100 grams to 3.37 grams per 100 grams for the average household, however, and there are slight decreases in the density of all other (unhealthy) nutrients. Our results also imply that VAT reform (1) would result in a 30 percent decrease in public revenues from VAT on grain products consumed by the average household.

If we instead implement a 50 percent subsidy on Keyhole labeled bread and breakfast cereals (i.e., VAT reform (2)), we achieve the recommended 38 percent increase in fiber intake. Further, our results suggest that the proportion of Keyhole labeled bread and breakfast cereals consumed, out of total bread and breakfast cereals, rises to almost 70 percent. The proportion of bakery products and ready meals, of total grain consumption, does not change, however. The amount consumed of bread and breakfast cereals would increase by 40 percent, while the

amount of bakery products and ready meals would rise by 6 percent. In addition, our results imply that the intake of unhealthy nutrients rises substantially, though by less than the fiber intake. The increase in salt and sugar intake is particularly high: 25 percent. However, the impact on dietary quality, as measured by the density of the nutrients, is more mixed. The density of fiber increases to 3.80 grams per 100 grams from 3.32 grams per 100 grams at baseline. The density of kilojoules, salt, and sugar also increases, whereas the density of all other nutrients decreases. Finally, the reform turns out to be costly, measured by public revenues lost: revenues from VAT on grain products paid by the average household decrease by 160 percent.

The simulated results of the fiber subsidy reform, which gives the same 38 percent increase in fiber intake as VAT reform (2), are given in column 4 of Table 6.1. Our results suggest that the proportion of Keyhole labeled bread and breakfast cereals consumed increases so that the nutritional recommendation is attained. The proportion of bakery products and ready meals remains the same as before the reform. Comparing the results in column 3 and 4, it is notable that the amount of bread and breakfast cereals consumed would increase by 11 percent under the fiber subsidy reform, which is much less than under VAT reform (2). Further, the amount consumed of bakery products and ready meals would decrease by 4 percent. The rise in the intake of fat, saturated fat, kilojoules, and added sugar would be higher than under VAT reform (2), whereas the increase in the intake of salt and sugar would be lower. The density of kilojoules would increase substantially to 989 kilojoules per 100 grams, whereas the density of salt, sugar, and added sugar would decrease substantially. There would be only small changes in the density of fat and saturated fat compared to baseline. Compared to VAT reform (2), the fiber subsidy reform is less costly, though it still imposes a sizeable burden on public revenues: the VAT and excise duty paid by the average household would decrease by 129 percent.

It should, however, be mentioned that the separability assumption between grain consumption and all other goods, imposed due to data limitations, may exaggerate the estimated change in amounts, since the real income increase that results from the subsidies is fully reallocated among the goods within the demand system. In reality, it is likely that some of the increase in real income is reallocated among other goods as well.

6.2 Effects of funded reforms

Subsidizing either commodities rich in fiber or the fiber content itself is not only costly in terms of lost revenue, it also leads to unwanted increases in unhealthy nutrients, as shown above. Governments might therefore consider policy packages that are revenue neutral and at the same time restrict the increase in unhealthy consumption. We therefore also simulate the results from revenue-neutral reforms, where subsidies of Keyhole labeled bread and breakfast cereals are funded by increased commodity taxes on particularly unhealthy grain products, namely bakery products and ready meals (see Table 3.2 for descriptive statistics on product contents). The reform entailing a subsidy on fiber content is funded by excise duties on other (unhealthy) nutrients. Funding, within the grain consumption demand system, could be achieved either by taxing one particular nutrient or a combination of unhealthy nutrients. Here we focus on analysis of tax schemes entailing a subsidy on fiber, funded by an excise duty on one single unhealthy nutrient: fat, saturated fat, sugars or added sugars.¹⁹

¹⁹ As noted earlier in this paper, salt is also overconsumed by the average consumer. However, salt is less efficient for tax purposes at present, as food is generally high in salt and substitutes for consumers therefore few, if seeking alternatives lower in salt (SNÖ, 2005). We therefore choose not to simulate the result of reforms entailing an excise duty on salt.

Our results imply that removing the VAT on Keyhole labeled bread and breakfast cereals could be funded by a VAT of 34.2 percent on bakery products and ready meals. The more extensive subsidy of Keyhole labeled bread and breakfast cereals would require a VAT level on bakery products and ready meals as high as 113.8 percent.

Funding the small VAT reform by a VAT levy of 34.2 percent on bakery products and ready meals results in an increase in the price of these products of 21 percent compared to baseline. For the same products, the price increases by 93 percent if funding the more sizeable VAT reform by imposing VAT of 113.8 percent on bakery products and ready meals.

Table A.2 shows the change in the overall price level for the average household due to selected funded reforms. Our results imply, for instance, that the overall price level for the average household decreases slightly, to 99 percent of the baseline price level, if the VAT on Keyhole labeled bread and breakfast cereals is removed and the VAT on bakery products and ready meals is raised to 34.2 percent. The more extensive funded VAT reform results in a decrease in the price level for the average household to 97 percent of baseline.

The changes in consumption and public revenues, resulting from the individual and overall price changes from these revenue-neutral policy packages, are shown in columns 1 and 2 of Table 6.2. Our results imply that both revenue-neutral VAT reforms result in the average household achieving the nutrition recommendation that half of bread and breakfast cereal consumption should be Keyhole labeled: the more extensive funded reform in fact leads to almost 70 percent of bread and breakfast cereals consumed by the average household being Keyhole labeled, should it be implemented. These results are very similar to the simulated impact on diets of the unfunded VAT reforms.

Table 6.2. The impact on the average household of funded VAT reforms

	Policy reform	
	VAT reform (1)F	VAT reform (2)F
Proportion of Keyhole labeled bread and breakfast cereals	0.50	0.69
Proportion of bakery products and ready meals	0.03	0.02
Relative change of amounts and intake of nutrients		
Amounts of bread and breakfast cereals	0.03	0.38
Amounts of bakery products and ready meals	-0.01	-0.10
Fiber	0.03	0.35
Fat	0.00	0.12
Saturated fat	-0.01	0.05
Kilojoules	0.01	0.17
Salt	0.01	0.21
Sugar	0.01	0.21
Added sugar	0.00	0.07
Density of nutrients in the grain diet		
Fiber/100 g grain purchases	3.38	3.84
Fat/100 g grain purchases	2.20	2.09
Saturated fat/100 g grain purchases	0.53	0.46
Kilojoules/100 g grain purchases	935.69	937.40
Salt in mg/100 g grain purchases	189.72	195.25
Sugars/100 g grain purchases	2.84	2.86
Added sugars/100 g grain purchases	1.09	0.95
Effects on public revenues		
Average relative change in VAT and excise duty paid in SEK	0.00	0.00

Note: VAT reform (1)F is the removal of VAT on Keyhole labeled bread and breakfast cereals, funded by 34.2 percent VAT on bakery products and ready meals. VAT reform (2)F is a 50 percent subsidy of Keyhole labeled bread and breakfast cereals funded by 113.8 percent VAT on bakery products and ready meals.

Our results also indicate that the smaller funded VAT reform results in an increase in the amount consumed of bread and breakfast cereals, as well as intake of fiber, of 3 percent. The change in other nutrients is minor.

The extensive funded VAT reform greatly increases the amounts of bread and breakfast cereals consumed by the average household – by as much as 38 percent (i.e., by only two percentage points less than the unfunded reform) – whereas amounts of bakery products and ready meals decrease by 10 percent. The substantial increase in amounts consumed as a result of the VAT reform is also reflected in the high increase in fiber intake – 35 percent – close to the recommended increase of 38 percent, which was attained when simulating the results from the corresponding unfunded reform. However, increases of other, unhealthy nutrients are still sizeable, though less than under the unfunded VAT reform, amounting to more than 20 percent for salt and sugar.

The impact on the quality of the grain diet, measured by the density of nutrients, is mixed. Comparing the densities in columns 1 and 2 in Table 6.2 with the densities at baseline (see Table 3.3), it is noteworthy that the density of fiber increases under both reforms, whereas the density of fat, saturated fat, and added sugar decreases under both reforms. The change in the densities is more pronounced if the more extensive VAT reform is implemented. Interestingly, the density of sugar, salt, and kilojoules also decreases under the smaller VAT reform, whereas these densities would either be unchanged or increase, probably due to a larger income effect, were the more extensive reform to be implemented. Compared to the unfunded VAT reforms (see Table 6.1), densities of fiber and kilojoules are higher under the funded reforms, whereas densities of all other nutrients are lower.

The SEK 0.046 subsidy per gram of fiber could be funded by either an excise duty of SEK 0.074 per gram of fat, an excise duty of SEK 0.325 per gram of saturated

fat, an excise duty of SEK 0.063 per gram of sugar, or an excise duty of SEK 0.182 per gram of added sugar. As expected, an excise duty per gram of saturated fat or added sugar must be higher than those of fat and sugar, respectively, in order to be part of a revenue-neutral policy package, since the content of saturated fat is lower than that of (total) fat and the content of added sugar is lower than that of (total) sugar.

Table A.3 shows the price changes under revenue-neutral policy packages with the SEK 0.046 subsidy per gram of fiber. The funded fiber subsidy reform results in sizeable price changes for many products, with most prices affected, even prices of products low in fat or sugar. As might be expected, prices of bakery products are greatly affected by fiber subsidies funded by excise duties on fat or sugar. Prices on ready meals are also greatly affected by reforms funded by excise duties on fat and saturated fat, but are almost unchanged by reforms funded by excise duties on sugar or added sugar. Also, the price of fresh filled pasta more than doubles from the reform funded by an excise duty on saturated fat, whereas the price of the same product even decreases (though slightly) if the reform is instead funded by an excise duty on added sugar. As for prices of bread and breakfast cereals in particular, the price of soft brown bread decreases if reforms are funded by excise duties on fat, saturated fat, or added sugar, whereas it increases slightly if the reform is funded by an excise duty on added sugar. The opposite is true for the price of white bread. It is notable that the price of sweet breakfast cereals and other breakfast cereals more than doubles with a reform funded by an excise duty on added sugar, compared to baseline. The price of flakes decreases slightly from reforms funded by excise duties on fat or saturated fat, whereas it increases sizably with reforms funded by excise duties on sugar or added sugar. The decrease in the price of Keyhole labeled breakfast cereals is greatest when the reform is funded by an excise duty on sugar, whereas the decrease is smallest if the reform is funded by an excise duty on fat or added sugar. Regarding the change in the overall price

level due to the funded fiber subsidy reform, Table A.2 shows that the SEK 0.046 subsidy per gram of fiber, per kilogram of grain product, coupled with a SEK 0.182 excise duty on added sugar, results in a 4 percent increase in the overall price level compared to baseline, whereas the same subsidy on fiber financed by a SEK 0.325 excise duty on saturated fat increases the price level by 2 percent. Compared to the average inflation rate over the last decade, these increases are fairly sizeable.

Columns 2-5 of Table 6.3 show how these price changes affect consumption. Also, for comparison, the changes in consumption resulting from the unfunded fiber subsidy are reported in column 1. Our results imply that all revenue-neutral reforms lead to the average household achieving the nutrition recommendation that half of bread and breakfast cereal consumption should be Keyhole labeled: the policy package entailing a subsidy on fiber funded by an excise duty on added sugar results in the highest proportion of Keyhole labeled bread and breakfast cereals, 54 percent. As expected, relative to baseline, the increase in amounts consumed is lower under the revenue-neutral reforms than under the unfunded fiber subsidy reform. It is noteworthy that a revenue-neutral policy package where the fiber subsidy is funded by an SEK 0.182 excise duty per gram of added sugar increases the fiber intake of the average household by twice as much as the revenue-neutral policy package where the fiber subsidy is funded by an excise duty of SEK 0.074 per gram of fat. The former policy package also results in an increase in fat and kilojoules for the average household that is greater than for any other policy package shown in Table 6.3; conversely, however, it also leads to sizeable reductions in the intake of sugar and added sugar in particular. As for the densities of the nutrients, the reforms resulting in the highest density of fiber in the grain diet of the average household are those funded by an excise duty on saturated fat and sugar, as shown by columns 3 and 4 in Table 6.3. The reform funded by an excise duty on grams of saturated fat also reduces the intake of saturated fat by 3 percent, while being more efficient in increasing the fiber intake than for example the

reform funded by an excise duty on grams of fat per kilogram of product. However, the reform with excise duty on added sugar results in the lowest density of salt, sugar and added sugar, and together with the reform funded by an excise duty on saturated fat, it also results in the lowest density of fat and saturated fat.

Table 6.3. Impact on the average household of funding the fiber subsidy reform

		Funding the SEK 0.046 subsidy per gram of fiber by imposing an excise duty of			
	Unfunded	SEK 0.074 per gram of fat	SEK 0.325 per gram of saturated fat	SEK 0.063 per gram of sugar	SEK 0.182 per gram of added sugar
Proportion of Keyhole labeled bread and breakfast cereals	0.51	0.51	0.52	0.52	0.54
Proportion of bakery products and ready meals	0.03	0.03	0.02	0.03	0.03
Relative change of amounts and intake of nutrients					
Amounts of bread and	0.11	0.04	0.04	0.03	0.03
Amounts of bakery products and ready meals	-0.04	-0.03	-0.06	-0.05	-0.10
Fiber	0.38	0.07	0.11	0.12	0.15
Fat	0.26	-0.01	0.01	0.03	0.05
Saturated fat	0.20	-0.03	-0.03	-0.01	0.00
Kilojoules	0.32	0.02	0.05	0.06	0.10
Salt	0.09	0.02	0.02	0.02	0.01
Sugar	0.19	-0.01	0.00	-0.04	-0.04
Added sugar	0.19	-0.01	-0.01	-0.06	-0.11

Table 6.3 continued:

Density of nutrients in the grain diet					
Fiber/100 g grain purchases	3.62	3.55	3.59	3.59	3.53
Fat/100 g grain purchases	2.24	2.20	2.17	2.21	2.17
Saturated fat/100 g grain purchases	0.52	0.52	0.50	0.52	0.50
Kilojoules/100 g grain purchases	988.67	948.73	961.69	953.55	957.97
Salt in mg/100 g grain purchases	175.54	194.18	191.22	189.00	182.48
Sugars/100 g grain purchases	2.74	2.81	2.75	2.57	2.44
Added sugars/100 g grain purchases	1.06	1.09	1.05	0.94	0.82
Effects on public revenues					
Average relative change in VAT and excise duty paid in SEK	-1.29	0.00	0.00	0.00	0.00

7. Conclusions

In this paper, we simulate the results of economic policy reforms designed to improve the quality of the modern grain diet. The policy objectives guiding our analysis are nutritional recommendations for grain consumption put forward by the Swedish National Food Administration (SLV). For the average consumer, SLV recommends doubling bread and breakfast cereal consumption, while ensuring that half of all bread and breakfast cereals consumed are labeled with the “Keyhole” symbol (a healthy label certified by SLV, based on the fat, fiber, salt, and sugar content of a product). Such changes in bread and breakfast cereal consumption would contribute to the overall objective of increasing the fiber intake by 38 percent. In addition, recommendations for food consumption as a whole state that

the average Swedish consumer should reduce his or her intake of fat, especially saturated fat, and salt, and not increase his/her added sugar consumption.

The average household is already close to achieving the recommendation that half of bread and breakfast cereal consumption should be Keyhole labeled, meaning that this is the easiest recommendation to attain. Our results suggest that a relatively small reform – for instance removing the VAT on Keyhole labeled bread and breakfast cereals – results in the average consumer achieving this recommendation. However, the associated increase in fiber intake is very modest.

Large price changes are necessary in order for the average household to achieve the recommended increase in fiber intake (or amounts) for grain consumption. For instance, to achieve a 38 percent increase in fiber intake, our results imply that a commodity subsidy of 50 percent on Keyhole labeled bread and breakfast cereals is required. Our results also imply that the same increase in fiber intake is more cost-efficiently achieved by a subsidy of the fiber content, instead of subsidizing products rich in fiber, even if both types of reforms are costly.

In addition, subsidizing products rich in fiber, or the fiber content, seems to lead to unwanted increases in nutrients that are likely to be overconsumed by the average consumer (fat, saturated fat, salt, sugar and added sugar), due to the income and substitution effects resulting from the reforms. This is in line with findings of Smed et al. (2007). A healthy diet might, therefore, be better achieved by reforms where subsidies of fiber, or products rich in fiber, are funded by taxes on less healthy commodities or nutrients. Our results imply that in order to fund the 50 percent subsidy of Keyhole labeled bread and breakfast cereals, the VAT on bakery products and ready meals must be substantial, however, approaching the level of Swedish VAT on tobacco. The increase in fiber intake from such a funded VAT

reform is considerable. However, increases in other (unhealthy) nutrients are still sizeable, even if reduced compared to the reform based on an unfunded subsidy.

We find that funding a subsidy of the fiber content (i.e., a subsidy per gram of fiber in each kilogram of grain product), either by an excise duty on added sugar or on saturated fat, has a good impact on the dietary quality of the average household: the increase in fiber intake is less than it would be if an unfunded fiber subsidy were imposed, but the funded fiber subsidy reform efficiently reduces the increase in the less healthy nutrients that results from the unfunded reform.

Finally, this study has limitations that are important to address in future research. First, the assumption of weak separability, between consumption of grain products and other goods, may overstate the increase in consumption of both healthy and unhealthy food products from reforms that yield increases in real expenditures. The weak separability assumption means that an increase in real expenditures is fully reallocated among the goods within the demand system. This is particularly the case for the large, unfunded, commodity subsidy as well as the fiber subsidy analyzed here. For the other reforms, the average change in real income is smaller and the effect of the separability assumption is of minor importance. Here, it should also be noted that the funded fiber subsidy reform that imposes taxes on the nutrients results in a fall in real expenditures on grain products for the average household as a result of the increase in the overall price level or Stone price index. Second, it should be noted that fruit and vegetables are food groups that are also relatively high in fiber, and could therefore be regarded as substitutes for grain products, if the aim is to increase the fiber density of the diet. Due to data limitations we have not been able to include these food groups in the analysis. Third, the supply side of the food market may absorb some of the change in the tax rate, which is not considered here. Therefore, it would also be of interest to study the effects of the tax changes within a general equilibrium framework.

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Appendix A

Table A.1. Comparison of average relative price changes after selected, unfunded policy reforms

	Policy reform		
	VAT reform (1)	VAT reform (2)	Fiber subsidy reform
Prices of bakery products			
Cakes	1.00	1.00	0.98
Sweet buns	1.00	1.00	0.98
Tarts	1.00	1.00	0.99
Prices of bread			
<i>Crisp bread</i>			
Keyhole labeled	0.90	0.50	0.75
White wheat	1.00	1.00	0.93
Brown	1.00	1.00	0.88
<i>Soft bread</i>			
Brown	0.90	0.50	0.93
White	1.00	1.00	0.96
Prices of breakfast cereals			
Flakes	1.00	1.00	0.95
Keyhole labeled	0.90	0.50	0.81
Muesli	1.00	1.00	0.83
Sweet cereals	1.00	1.00	0.97
Others	1.00	1.00	0.97
Prices of staple goods for			
Wholegrain flour	1.00	1.00	0.51
Flour for sauces	1.00	1.00	0.94
Keyhole labeled flour	1.00	1.00	0.45
White wheat flour	1.00	1.00	0.53
Dough	1.00	1.00	0.98
Prices of pasta			
Fresh filled	1.00	1.00	0.96
Fresh unfilled	1.00	1.00	0.98
Filled	1.00	1.00	0.98
Unfilled	1.00	1.00	0.95
Wholegrain	1.00	1.00	0.93
Prices of ready meals			
Pancakes	1.00	1.00	0.99
Pirogues, pan pizza	1.00	1.00	0.99
Pizza, pasta, lasagne	1.00	1.00	0.99
Spring rolls	1.00	1.00	0.99
Others	1.00	1.00	0.99

Table A.1 continued:

Prices of rice			
Easy-cook	1.00	1.00	0.99
Brown	1.00	1.00	0.98
White	1.00	1.00	0.98
Others	1.00	1.00	0.96

Table A.2. Price changes for the average household from selected policy reforms

Unfunded reforms		
VAT reform (1)		0.9
VAT reform (2)		0.8
Fiber subsidy reform		0.9
Funded reforms		
VAT reform (1)F		0.99
VAT reform (2)F		0.97
Fiber subsidy funded by excise duty on added sugar		1.04
Fiber subsidy funded by excise duty on saturated f		1.02

Table A.3. Impact on prices of funded reforms entailing a fiber subsidy of SEK 0.0460 per gram of fiber

		Funding the 0.0460 subsidy per gram of fiber by imposing an excise duty of			
	Unfunded	SEK 0.0740 per gram of fat	SEK 0.3250 per gram of saturate d fat	SEK 0.0630 per gram of sugar	SEK 0.1820 per gram of added sugar
Prices of bakery products					
Cakes	0.98	1.25	1.29	1.24	1.64
Sweet buns	0.98	1.26	1.48	1.12	1.20
Tarts	0.99	1.17	1.36	1.19	1.44

Table A.3 continued:

Prices of bread					
<i>Crisp bread</i>					
Keyhole labeled	0.75	0.82	0.80	0.79	0.79
White wheat	0.93	1.09	1.09	1.01	0.95
Brown	0.88	0.95	0.95	0.93	0.89
<i>Soft bread</i>					
Brown	0.93	0.98	0.97	1.02	0.94
White	0.96	1.03	1.02	1.02	0.97
Prices of breakfast cereals					
Flakes	0.95	0.99	0.98	1.18	1.41
Keyhole labeled	0.81	0.93	0.89	0.87	0.93
Muesli	0.83	1.08	1.25	1.36	1.77
Sweet cereals	0.97	0.99	0.99	1.55	2.20
Others	0.97	0.99	0.99	1.55	2.22
Prices of staple goods for cooking					
Wholegrain flour	0.51	0.90	0.72	0.92	0.75
Flour for sauces	0.94	0.96	0.95	0.97	0.98
Keyhole labeled flour	0.45	0.72	0.62	0.54	0.61
White wheat flour	0.53	0.92	0.77	0.80	0.69
Dough	0.98	1.74	2.41	1.00	0.99
Prices of pasta					
Fresh filled	0.96	1.61	2.23	1.02	0.99
Fresh unfilled	0.98	1.01	1.02	0.99	0.98
Filled	0.98	1.22	1.36	1.01	1.00
Unfilled	0.95	0.99	0.96	0.96	0.97
Wholegrain	0.93	0.95	0.94	0.94	0.94
Prices of ready meals					
Pancakes	0.99	1.13	1.25	1.05	0.99
Pirogues, pan pizza	0.99	1.31	1.60	1.01	1.00
Pizza, pasta, lasagne	0.99	1.11	1.21	1.01	1.00
Spring rolls	0.99	1.15	1.19	1.03	1.00
Others	0.99	1.18	1.36	1.01	1.00
Prices of rice					
Easy-cook	0.99	1.00	1.00	1.00	1.01
Brown	0.98	1.00	1.00	0.99	1.00
White	0.98	1.00	1.01	0.99	1.00
Others	0.96	1.01	1.02	0.98	1.01

Appendix B

For each person or household, the uncompensated price elasticity for a product within each separate demand system is given by

$$e_{fg} = \gamma_{fg} / s_f - (\beta_f + 2\delta_f \ln m) \times (s_f / s_g) - \kappa_{fg} \quad (\text{B.1})$$

where $\kappa_{fg} = 1$ if $f = g$ and $\kappa_{fg} = 0$ if $f \neq g$, and m is real expenditures. To simplify the expressions, the household index is suppressed. The expenditure elasticity is

$$E_f = (\beta_f + 2\delta_f \ln m) / s_f + 1 \quad (\text{B.2})$$

With positive β and negative δ , equation (B.2) shows that the expenditure elasticity may exceed 1 for households with low expenditures on the good, indicating that it is a luxury good, whereas households with higher expenditures may have an expenditure elasticity less than 1, thereby considering the product to be a necessary good. To calculate the set of compensated elasticities we use the Slutsky equation $e_{fg}^c = e_{fg} + s_g E_f$. In the case of two-stage budgeting, the total uncompensated price elasticity is given by (Edgerton, 1997)

$$e_{ij} = \kappa_{kl} e_{(k)ij}^c + E_{(k)i} s_{(l)j} e_{(k)(l)} \quad (\text{B.3})$$

where $e_{(k)ij}^c$ is the compensated price elasticity between good i and j in the k 'th group, $E_{(k)i}$ is the expenditure elasticity for good i in the k 'th group, and $e_{(k)(l)}$ is the uncompensated price elasticity between good k and l at the first allocation stage. The total expenditure elasticity is

$$E_i = E_{(k)} E_{(k)i} \quad (\text{B.4})$$

where E_k is the expenditure elasticity for the k 'th group at the first allocation stage. If we extend the analysis to three-stage budgeting, the expression for the uncompensated price elasticity becomes

$$\begin{aligned} e_{ij} = & \kappa_{ab} \kappa_{kl} e_{[a](k)ij}^c + \kappa_{ab} s_{[b](l)j} E_{[a](k)i} e_{[a](k)(l)}^c \\ & + s_{[b](l)j} s_{[b](l)} E_{[a](k)i} E_{[a](k)} e_{[a][b]} \end{aligned} \quad (\text{B.5})$$

where the notation $[a][b]$ refers to the first allocation stage, and $(k)(l)$ to the second allocation stage. The total expenditure elasticity is given by

$$E_i = E_{[a]} E_{[a](k)} E_{[a](k)i} \quad (\text{B.6})$$

IV

Preference Heterogeneity and Habit Persistence:

*The Case of Breakfast Cereal Consumption**

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Abstract

This paper estimates the strength and heterogeneity across households in state dependence associated with breakfast cereal consumption, where positive state dependence implies habit persistence and negative state dependence implies variety-seeking in consumption. The analysis relies on a discrete choice model and finds that breakfast cereal consumption is generally highly habitual, but the degree of habit persistence exhibits heterogeneity across households. In addition, some households can be characterized as variety-seeking. The strength of habit persistence is similar across income and educational groups. The strength of habit persistence seems to be weaker for households with several adults and children compared to one-adult-households.

Keywords: consumer choice; habit persistence; food consumption; preference heterogeneity

JEL classification: D12; C35

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1. Introduction

Recently, modern diets have become a major concern among researchers, public health experts and policy makers. The modern diet, often characterized by a poor nutritional content and a high amount of so called “empty calories,” has contributed to the increased prevalence of a number of serious illnesses and subsequent costs for individuals and society.¹ A high consumption of empty calories means frequent sharp rises in blood glucose (sugar) concentrations, which is associated with an increased risk for type 2 diabetes (Salmeron et al., 1997a and 1997b) and cardiovascular disease (Liu et al., 2000). In contrast, a high intake of whole grain products has several health-promoting effects. For example, it has been shown to reduce the risk of obesity (Liu et al., 2003), itself a major risk factor for type 2 diabetes, cardiovascular disease, and colorectal cancer (Schatzkin et al., 2007).

Launching information campaigns that make consumers aware of the positive health effects from choosing food that is rich in whole grain may be of interest to policy makers and producers. Some health advocates have suggested incentives for redirecting food consumption, such as food taxes. However, the efficiency of both information campaigns and economic policies will be affected by the degree of habit persistence in food consumption.

¹ Direct costs on health care (costs of in- and outpatient care and pharmaceutical therapy) from poor nutrition and too little exercising are estimated to account for 7 percent of personal health care expenditures in the U.S. (Kenkel and Manning, 1999). In Sweden, the direct costs on the public health care system of obesity and overweight alone has been estimated to be SEK 3.6 billion (Persson et al. 2004), and the corresponding indirect costs (the value of lost production, due to sick leave, disability pension and early deaths) to be SEK 12.4 billion (Persson and Ödegaard, 2005), amounting to about 3 percent of total indirect and direct costs of all illnesses (Socialstyrelsen, 2003). Diet-related costs on society are likely to increase even further, due to the time lag between poor dieting and the development of severe illnesses. These developments have put pressure on policy makers to consider policies that encourage healthier food consumption.

This paper examines the strength and heterogeneity in the habit persistence associated with breakfast cereal consumption. Studies show (e.g. Jenkins et al., 1982, and Liljeberg et al., 1999) that the choice of breakfast affects the blood glucose response not only to the morning meal itself, but also to subsequent meals during that day. The choice of breakfast is, therefore, an important decision for those in charge of household purchases. Nilsson et al. (2008) analyze the health benefits from consuming different types of breakfast cereals specifically. Using a breakfast containing white-wheat bread as the baseline, they show that whole-grain cereal products for breakfast notably increase the glucose tolerance, i.e. stabilizes the blood glucose levels throughout the day. Therefore, a regular diet of whole-grain cereal products for breakfast reduces the risk of type 2 diabetes and cardiovascular disease.

To analyze habit persistence in breakfast cereal consumption, a mixed multinomial logit model (also known as the random parameters logit model) is applied to Swedish household panel data on breakfast cereal purchases. The model allows for state dependence, where a positive state dependence implies habit persistence in consumption, whereas a negative state dependence implies variety-seeking.

Pollack (1970) notes that goods are associated with habit persistence if current preferences depend on past consumption.² Thus, habit persistence means that past consumption reinforces the propensity to consume the same good over time. If food consumption is habitual, short and long term responses to income and price changes, and possibly also information campaigns, will differ (even if the underlying decision problem lacks other intertemporal aspects). If consumption is associated with habit persistence, price changes or information campaigns will lead to changes in consumption, which will lead to changes in tastes, which, in turn, will

² We choose to use the term ‘habit persistence’ instead of ‘habit formation’, since we do not address the formation of habits as such.

lead to further changes in consumption. In other words, in the short run, consumption is sticky, and adjusts less by comparison with the long run response (which also reflects adjustments of habits). If the habit persistence is strong, policies designed to affect consumption will, therefore, be more costly, and price changes will have little effect in the short run, compared to cases where the habit persistence is weak. A negative state dependence, on the other hand, implies variety-seeking. Consumers that seek variety in food consumption experience satiety over time from the attributes associated with a good, which creates incentives to change the consumption behavior. The short and long term effects on consumption of information campaigns and price instruments may, therefore, depend on whether or not consumption is driven by habit persistence or by variety-seeking.

Research on habits in food consumption has largely been based on aggregate data. The reason for this might be lack of access to adequate micro level data (Carrasco et al., 2005, and Browning and Collado, 2007). A few studies have focused on habit persistence in consumption, using micro level data (e.g. Alessie and Kapteyn, 1991, Meghir and Weber, 1996, Dynan, 2000, Carrasco et al., 2005, and Browning and Collado, 2007). Evidence of habit persistence in food consumption from these studies is mixed. Carrasco et al. (2005) find evidence of habit persistence in aggregate food consumption, whereas Alessie and Kapteyn (1991), Meghir and Weber (1996) and Dynan (2000) do not. Browning and Collado (2007) find that aggregate food consumed away from home exhibits habit persistence, whereas food consumed at home does not. However, the level of product aggregation in these studies is high, which makes the results less useful as a basis for policy design - particularly if the policy instruments are designed to target consumption of certain food categories. By aggregating the consumption of food categories associated with varying degrees of habit persistence, habits may be difficult to detect.

Studies on detailed product data that contain measures of state dependence and use discrete choice models are mainly found in the marketing literature on brand choice; see Chintagunta (1993), Erdem (1996), Ailawadi and Neslin (1998), Sun et al. (2003) and Seetharaman (2004). These studies analyze brand choice on (mainly region-specific) US micro level data, containing selected brands. The food product categories covered by these studies are margarine, peanut butter, ketchup and yoghurt. Seetharaman defines the influence of the previous purchase on the propensity to purchase the same brand as “structural habit persistence”. The results from the above mentioned studies suggest habit persistence associated with brands or attributes in the consumption of all food groups mentioned.

A few recent studies use mixed multinomial logit models to analyze unobserved preference heterogeneity in food demand; Nevo (2001) and Chidmi and Lopez (2007) estimate mixed multinomial logit models on breakfast cereal scanner data, whereas Andersen (2006) estimate a mixed multinomial logit model using household panel data on the demand for eggs. Neither of the studies allows for habit persistence, but all find evidence of heterogeneity in consumer preferences over breakfast cereals.

The present study contributes to the literature in two ways. It is the first study exploring habit persistence on data where healthy and unhealthy food products are identified. Second, it is the first study allowing for heterogeneity in habit persistence on data that contains both detailed product information and background information on consumers. Therefore, we are able to explore the extent to which household characteristics explain the heterogeneity in state dependence, i.e. we identify differences in state dependence over household groups. Knowledge on variations in habit persistence over household groups is valuable to policymakers who wish to give priority to certain households in the design or implementation of

policy.³ The results generated by this study may help in identifying the Swedish consumer groups that are likely to be most responsive – in the short run – to policies designed to influence the nutritional value of breakfasts.

The structure of the paper is as follows. Section 2 presents the data, Section 3 describes the empirical method, and Section 4 provides the estimation results. Section 5 contains concluding remarks.

2. Data

The study relies on household panel data for daily breakfast cereal consumption during year 2003, obtained from the market research institute GfK Sweden⁴. One member of each household in the panel is assigned the responsibility of reporting food purchases on a detailed level. Product characteristics of the breakfast cereals are reported by the sample households, and include the price of the product purchased, date of purchase, brand, package size and the number of packages bought. The number of breakfast cereal products in the sample amounts to 181. The detailed data allow us to match each product with its nutritional content, by using the database maintained by the Swedish National Food Administration (SLV). Each product is matched with its content of fat, saturated fat, fibre, salt, sugar and added sugar (measured per 100 grams of product).

To simplify the analysis of choice determinants for different cereals, we group the 181 breakfast cereals into 5 categories, based on product content and

³ For instance, Nordström and Thunström (2008) show that households with children have a lower consumption share of healthy bread and breakfast cereals than households without children. Encouraging families with children to improve their diets might therefore be a priority. Another reason for giving priority to families with children emerges if habits are formed at an early age and are likely to stick over the life cycle.

⁴ GfK ('Growth from Knowledge') is a private market research company.

characteristics: *flakes*, *Keyhole labelled (particularly healthy) breakfast cereals*, *muesli*, *sweet breakfast cereals* and *others*.⁵ The main variation of characteristics between these groups is in sugar and fibre contents. Table 1 shows summary statistics (min, mean and max values) of the product characteristics for the products in each category. For example, the price of the cheapest Keyhole-labelled product purchased (by all households in the sample) was SEK 3.45 per 100 gram, whereas the price of the most expensive Keyhole-labelled product was SEK 6.95 per 100 gram. The mean price over the year for Keyhole-labelled cereals was SEK 5.21.⁶ The average fibre content is higher in the muesli category than in Keyhole-labelled breakfast cereals. However, the fibre-rich products in the muesli category did not meet the Keyhole label criteria for sugar content. The product content is used to divide the breakfast cereals into their respective groups but, as will be shown later, the product content is not used in the econometric analysis, due to too little variation in the fibre and sugar content within the groups.

⁵ The Keyhole is a nutrition symbol certified by the Swedish National Food Administration (SLV) that identifies healthy food alternatives. In 2003, breakfast cereals obtained a Keyhole symbol if they fulfilled the following criteria: sugar max 13g/100g and fibre min 9g/100g (SLVFS,1989:2). In our sample, the products included in the Keyhole group are those breakfast cereals that fulfil these criteria (mainly flakes and muesli). The flakes group contains flakes (other than Keyhole labelled) that are non-sweet (e.g. cornflakes and bran flakes), whereas the sweet flakes (e.g. frosties) are included in the sweet breakfast cereal group. The latter group also contains all breakfast cereals that are primarily marketed as kids cereals. The products in the muesli group (i.e. the muesli without the Keyhole label) range from very basic muesli to different types of muesli with both berries and fruit and roasted ingredients.

⁶ Keyhole labelled muesli is relatively cheap, whereas Keyhole labelled flakes are relatively expensive.

Table 1. Breakfast cereal characteristics

		Breakfast cereal type				
Characteristic		Flakes	Keyhole labelled	Muesli	Sweet cereals	Others
Price in SEK per 100 gram	min	4.17	3.45	2.69	4.56	3.84
	mean	4.72	5.21	3.50	5.28	5.28
	max	5.21	6.95	3.89	6.23	11.29
Grams of fibre per 100 gram	min	1.8	9.7	6.8	1.2	0.8
	mean	3.4	10.5	10.7	2.6	5.9
	max	14.7	11.0	14.7	4.0	7.7
Grams of sugar per 100 gram	min	9.3	1.8	17.0	9.4	0.4
	mean	13.6	7.2	23.4	38.5	24.3
	max	38.0	11.0	24.8	45.9	38.0

Household characteristics in the sample include the level of education and gender of the household member mainly responsible for food purchases, the pre-tax labour income⁷ of the household, the number of household members and the number of children age 16 or younger. The measure of household income refers to the pre-tax labor income in 2003 and is presented in such a way that the households are divided into income groups. Households with a maximum income of SEK 199,999 belong to income group 1, whereas households in income groups 2, 3 and 4 have an income of SEK 200,000-299,999, SEK 300,000-499,999 and minimum SEK 500,000 respectively. Households are divided into three educational groups, based on the highest level of education of the person in charge of household purchases; elementary schooling, high school education and higher education

⁷ Reported in 2003 years prices.

(university/college).⁸ Also, households are divided into household types; single adult (man or woman) with no children, single adult with children, two adults with no children, two adults with one child, two adults with two or more children, and three or more adults (with or without children), where adult is defined as above 16 years old. Table A1, Appendix A, provides an overview of the variable definitions.

In 2003, 1,336 households in the GfK panel purchased grain products for the full year, of which 926 purchased breakfast cereals. These households purchasing breakfast cereals constitute our population and the basis for our analysis. The panel is highly unbalanced, with the frequency of reported annual household breakfast cereal purchases ranging between 1 to 123, with the highest numbers representing extreme cases. The average number of purchases made by the sample households over the year is 12. All in all, the panel used in the analysis consists of 11,109 observations.

Following previous studies (e.g. Erdem, 1996, Seetharaman, 2004, and Andersen, 2006), we choose not to include a zero-purchase option, meaning that we exclude households who do not purchase breakfast cereals during the study period. Households always have the choice not to make a purchase, so choice occasions for a zero-purchase option are difficult to define. It is unlikely that households who are breakfast cereal consumers purchase breakfast cereals less frequently than once a year. The selection bias created by excluding households who have not purchased breakfast cereals during 2003 is therefore likely to be small. Even though we make no attempt to generalize our findings beyond breakfast cereal consumers, Appendix A contains a comparison of the relative shares of the household types in our

⁸ Note that the level of education is reported by the households. In the questionnaire, it is not specified whether, for instance, “higher education” means having taken courses at the university or having a degree from a university. To be more specific, the households were asked to mark their “highest ongoing or finished education”, among the alternatives summarized by the dummy variables representing educational levels.

sample, to the relative share of the same household types in the grain consumer panel as a whole (see Table A2, in Appendix A). The demographic profile of the households included in our analysis is similar to the profile of households in the full grain consumer GfK panel. The share of households with children, and the share of households belonging to the higher income groups, are, however, slightly higher in our sample during the study period.⁹

Table 2 shows descriptive statistics of the shares purchased of different types of breakfast cereals by each household type. The numbers refer to the share of respective cereal types out of the total cereal consumption (in grams) for each household type. Of all breakfast cereals purchased by our sample in 2003, 39 percent were muesli, 33 percent were flakes, 15 percent were sweet cereals and 8 percent were Keyhole-labelled breakfast cereals. Dividing the households by income group, Table 2 shows that the two lowest income groups have a slightly higher percentage of Keyhole-labelled purchases (9 percent), as part of their total breakfast cereal purchases during the year than do the two higher income groups (7 percent).

Grouping the sample households by educational level of the household member mainly responsible for food purchases, we find that the consumption share of Keyhole-labelled breakfast cereals is higher in households where the purchaser has at least a high school education (9 percent), compared to households where the purchaser has an elementary school education (6 percent). Also, the consumption

⁹ We have also estimated a probit model based on the full grain GfK panel, where the decision to purchase/not to purchase breakfast cereals is a function of breakfast cereal prices and household characteristics. Compared to a model with no regressors (i.e. with only a constant), the probit model is statistically significant (LR value = 112, p -value = 0.000). The explanatory power of the model is relatively modest, though, with an R-squared value of 0.08. Commenting on the statistically significant (at the 5 percent level) variables only, the probit results imply that the probability of purchasing breakfast cereals increases with the number of children and with income.

share of muesli is higher for the sample households belonging to the higher educational groups, whereas the opposite is true for flakes. The consumption share of sweet cereals is the highest for households with a high school education, compared to households belonging to both the higher and lower educational group.

Dividing the sample households by household type (i.e. combination of adults and children), Table 2 shows that the relative share of sweet cereals for households with children is sizeable (for a single adult with children, as high as 35 percent), whereas it is low (6 percent) for single adults with no children. Households consisting of a single adult without children also purchase the highest share of Keyhole-labelled breakfast cereals (12 percent) of all household types.

Table 2. Relative shares of breakfast cereal purchases by household groups

	Breakfast cereal type					<i>Sum</i>
	Flakes	Keyhole-labelled	Muesli	Sweet cereals	Others	
Relative market shares, all households	0.33	0.08	0.39	0.15	0.05	<i>1.00</i>
Relative market shares by income per household						
Income group 1 (lowest)	0.31	0.09	0.43	0.13	0.04	<i>1.00</i>
Income group 2	0.35	0.09	0.38	0.11	0.06	<i>1.00</i>
Income group 3	0.34	0.07	0.37	0.16	0.05	<i>1.00</i>
Income group 4 (highest)	0.31	0.07	0.43	0.16	0.03	<i>1.00</i>

Table 2 continued:

Relative market shares by level of education for household member responsible for food purchases						
Elementary schooling	0.42	0.06	0.35	0.13	0.06	1.00
High school education	0.32	0.09	0.39	0.17	0.04	1.00
Higher education	0.30	0.09	0.43	0.13	0.05	1.00
Educational level n.a.	0.33	0.02	0.45	0.16	0.03	1.00
Relative market shares by household type						
Single adult, no children	0.32	0.12	0.46	0.06	0.04	1.00
Single adult with children	0.15	0.08	0.37	0.35	0.05	1.00
Two adults, no children	0.41	0.07	0.43	0.06	0.04	1.00
Two adults with one child	0.27	0.06	0.43	0.19	0.06	1.00
Two adults with two or more children	0.30	0.08	0.31	0.24	0.06	1.00
Three or more adults	0.33	0.07	0.36	0.20	0.05	1.00

Note: n.a. = not available, meaning that households did not report the category they belong to.

3. An Empirical Approach to Consumer Choice

The mixed multinomial logit model (MMNL) is well suited for our purposes due to the flexibility provided by the model and its ability to handle panel data. The MMNL shares some of the features of the more commonly used, but also more restrictive, multinomial logit model (MNL).

The MMNL, as well as other models in the family of multinomial logit models, are derived from the theoretical framework provided by the random utility model (RUM). In the RUM, the utility of a choice alternative, j , for household n in period t , is determined by factors that are observed by the researcher, x_{njt} , and factors that

are unobserved by the researcher, ε_{njt} . The unobserved part of utility, ε_{njt} , is defined as a random variable. It should be noted that ε_{njt} is assumed to be known to the household. The utility that the household associates with a particular choice alternative is, therefore, not subject to randomness. The household chooses among J options the alternative from which it derives the highest utility.¹⁰

In a MNL, the unobserved part of the utility mentioned above (i.e. the error term) is assumed to be extreme value as well as identically and independently distributed (iid). The iid assumption means no correlation between error terms over alternatives, i.e. the unobserved utility component associated with alternative j , ε_{njt} , does not affect the utility of any other choice alternative, and there is no correlation of error terms over time. The iid assumption, in turn, gives rise to the Independence of Irrelevant Alternatives (IIA) property, which states that the ratio of probabilities of any two alternatives in the model will remain unchanged, regardless of whether new alternatives are introduced or existing alternatives are excluded from the choice set. Assume, for instance, that Keyhole-labelled muesli was removed from the market. From the IIA property it then follows that the households that previously purchased Keyhole-labelled breakfast cereals would divide themselves over the other breakfast cereal types in proportion to the relative shares of these breakfast cereals, such that the probability ratios are kept constant. However, households that previously purchased Keyhole-labelled breakfast cereals might differ from the general population and exclusively buy muesli and flakes (and no sweet cereals), if Keyhole-labelled breakfast cereals were not available. The IIA associated with the MNL, therefore, imposes unnecessary and often implausible restrictions on the substitution patterns of households. A more flexible model that relaxes the iid assumption (and, as a consequence, the IIA) is desirable.

¹⁰ Here, it is assumed that the choice made by the household is the choice that gives the highest joint utility for all household members.

The MMNL fully relaxes the iid assumption, and hence lacks the restrictions imposed by the IIA property.¹¹ Depending on the specification, the MMNL allows the unobserved part of the utility to be correlated over time and over alternatives. Another appealing feature of the MMNL, as demonstrated below, is that it allows for heterogeneity in preferences over consumers. MMNL calculations are very computer intense, which explains their limited use until relatively recently. Applications of MMNL models on panel data include Erdem (1996), Bath (1997), Revelt and Train (1998), and Johannesson and Lundin (2002).

The behavioural specification of the MMNL can vary extensively and, depending on the specification of the model, the MMNL can approximate any discrete choice model (McFadden and Train, 2000). For instance, a MMNL where all parameters are fixed collapses to a MNL and Hensher et al. (2007) show that a MMNL defined as an error components model approximates the nested logit model.

In the MMNL, household n 's indirect utility of purchasing breakfast cereal type j at time t is defined as

$$U_{njt} = \beta_n' x_{njt} + \varepsilon_{njt} = (\bar{\beta}' + \mu_n') x_{njt} + \varepsilon_{njt} = \bar{\beta}' x_{njt} + \mu_n' x_{njt} + \varepsilon_{njt} \quad (1)$$

where the parameter vector β_n is assumed to be household specific, i.e. the preferences may be heterogeneous over households. The parameter vector β_n consists of two parts: $\bar{\beta}$, which is common to all households and equal to the mean of the distribution of all individual β_n s, and a household-specific error term, μ_n ,

¹¹ Andersen (2006) provides analytical proof of a single random coefficient being sufficient for the IIA property not to hold.

with zero mean.¹² The parameter β_n is distributed in the population with density $f(\beta_n|\theta)$, where θ represents the parameters of the distribution for β_n (i.e. the mean and the variance). The functional form, $f(\cdot)$, is specified by the researcher. Note that in the MMNL, the unobserved part of utility consists of $\xi_{njt} = \mu_n' x_{njt} + \varepsilon_{njt}$. As in the MNL, the error term ε_{njt} is assumed to be iid extreme value. The distribution of μ_n , on the other hand, may differ from iid extreme value.

Suppose that the household faces a sequence of repeated choices over time. Let i denote the observed choice by household n at time t . Conditional on β_n , the probability of household n choosing alternative i at time t is the standard logit formula, $L_{nit}(\beta_n) = e^{\beta_n' x_{nit}} / \sum_j e^{\beta_n' x_{njt}}$ (i.e. the MNL choice probability, see McFadden, 1981). The conditional choice probability of household n 's sequence of observed choices over time is then the product of the individual logit formulas from each choice occasion $t=1, \dots, T$. By integrating the conditional choice probability over all possible values of β_n , we have the unconditional choice probability of household n making the observed choice sequence

$$P(y_n|x, \theta) = \int_{\beta_n} \prod_{t=1}^T \left(\frac{e^{\beta_n' x_{nit}}}{\sum_j e^{\beta_n' x_{njt}}} \right) f(\beta_n|\theta) d\beta_n = \int_{\beta_n} \prod_{t=1}^T L_{nit}(\beta_n) f(\beta_n|\theta) d\beta_n \quad (2)$$

¹² Here, we assume that taste is stable over time (i.e. year 2003), but varies over individuals, such that the random taste parameter β_n varies over households, and not over time. It should also be noted that the parameters contained in β_n may be either alternative specific or generic over alternatives.

Given the purpose of our study, there are a couple of particularly appealing features of the MMNL. First, lagged dependent variables can enter the model without revising the estimation procedure. As highlighted by Train (2002), conditional on β_n , the remaining error terms, ε_{jnt} , are iid extreme value distributed, i.e. independent over time. A lagged dependent variable in the utility function will, therefore, be uncorrelated with the error terms ε_{jnt} at time t and the unconditional MMNL choice probabilities remain as stated in equation (2). Second, the MMNL makes it possible to control for unobserved preference heterogeneity, which is important from the point of view of identifying “true state dependence”.¹³

The household-specific likelihood functions are assumed to be independent, such that the likelihood function to be maximized in the MMNL is the product of all household specific likelihood functions, defined as

$$L = \prod_{n=1}^N \int_{\beta_n} \prod_{t=1}^T L_{nit}(\beta_n) f(\beta_n | \theta) d\beta_n \quad (3)$$

Our aim is to use maximum likelihood estimation to estimate θ , the parameters describing the distribution of individual β_n in the population. The integral in equation (3) has no closed form solution, i.e. cannot be calculated analytically, and hence the choice probabilities are approximated through simulation. For further

¹³ Heckman (1981) stresses that choice persistence may be a result of both state dependence and preference heterogeneity. Specific characteristics (for instance, having diabetes) may result in a consumer repeatedly choosing non-sweet breakfast cereals. In this case, the choice of non-sweet breakfast cereals is not reinforced by previous choices (i.e. “true state dependence”), but would merely be a result of consumer background variables. In order to identify state dependence, it is therefore important to control for preference heterogeneity.

details on the procedure and properties of the simulated choice probabilities, see e.g. Revelt and Train, 1998, Hensher and Greene, 2003, and Hensher et al., 2005.¹⁴

4. Estimation and results

The utility of each choice alternative (*flakes*, *Keyhole-labelled breakfast cereals*, *muesli*, *sweet breakfast cereals* and *others*) is assumed to be affected by the price of the particular choice alternative and state dependence, where state dependence is represented by dummy variables for the purchases of the previous and second-previous choice occasions.

To explore the data prior to model specification, we start by estimating an MNL with alternative specific fixed parameters. Of particular interest is whether there is a difference in parameters associated with state dependence for the healthy (Keyhole-labelled) alternative and the unhealthy (sweet) alternative, compared to other breakfast cereal types. We conduct Wald tests with the null hypotheses that the parameters for (i) the dummy variable indicating the previous purchase and (ii) the dummy variable indicating the second-previous purchase are different between Keyhole-labelled and sweet breakfast cereals, respectively, and other breakfast cereal types. In all cases, we reject the null hypotheses and conclude that, at the 95 percent confidence level, the point estimates of the parameters associated with the

¹⁴ In brief, β_n is drawn repeatedly (R times) from its distribution $f(\beta_n | \theta)$. Each value drawn is labelled β_r , where $r = 1, \dots, R$, and inserted in the following simulated mixed logit choice probability $\hat{P}(y_n | x, \theta) = \frac{1}{R} \sum_{r=1}^R \prod_{t=1}^T L_{nit}(\beta_r)$. As stated by Revelt and Train (1998), $\hat{P}(y_n | x, \theta)$ is an unbiased estimator of $P(y_n | x, \theta)$. The parameters are estimated by simulated maximum likelihood. This is done by inserting $\hat{P}(y_n | x, \theta)$ into equation (3), instead of the exact choice probability.

dummy variable are equal across alternatives. We therefore estimate generic parameters for all alternatives.

We estimate the following model

$$U_{njt} = \alpha_{nj} + \gamma_n' D_{ppj,t-1} + \delta_n' D_{ppj,t-2} + \psi' P_{jt} + \varepsilon_{njt} \quad t = 1, \dots, T \quad (4)$$

where U_{njt} is the indirect utility of alternative j ($j = \text{flakes, Keyhole-labelled breakfast cereals, muesli, sweet breakfast cereals or others}$), for household n at choice occasion t . The parameter α_{nj} is the alternative specific constant; $D_{ppj,t-1}$ is a dummy variable that takes the value 1 if alternative j was purchased on the previous choice occasion and zero otherwise; $D_{ppj,t-2}$ is a corresponding dummy variable for having purchased j on the second previous choice occasion, and P_{jt} is the price of alternative j .¹⁵

The household specific parameters, α_n , γ_n and δ_n , consist of two parts; a mean value that is common to all households, and a household specific deviation from the mean. The price parameter is assumed to be fixed over both households and alternatives. Equation (4) can, therefore, be rewritten

¹⁵ Most of the previous studies using a similar methodology to capture state dependence (e.g. Chintagunta, 1993, Erdem, 1996, Ailawadi, 1998, and Sun et al., 2003) include in the model the most recent lagged choice only. However, Seetharaman (2004) shows that restricting the number of lags to only one may lead to biased estimates of the parameters associated with state dependence. Therefore, we choose to include two lags in the model. It should also be noted that the state dependence modelled here means that households could be referred to as “naïve”, in the sense that, when making the choice of breakfast cereal at time t , they consider their consumption history, but do not recognize the impact of present consumption on future tastes.

$$\begin{aligned}
U_{njt} &= (\bar{\alpha}_j + \omega_{nj}) + (\bar{\gamma} + \eta_n)' D_{ppj,t-1} + (\bar{\delta} + \mu_n)' D_{ppj,t-2} + \psi' P_{jt} + \varepsilon_{njt} = \\
&\bar{\alpha}_j + \bar{\gamma}' D_{ppj,t-1} + \bar{\delta}' D_{ppj,t-2} + \psi' P_{jt} + \underbrace{\omega_{nj} + \eta_n' D_{ppj,t-1} + \mu_n' D_{ppj,t-2}}_{\text{Unobserved part of utility}} + \varepsilon_{njt}
\end{aligned} \tag{5}$$

Each of the parameters ω_{nj} , η_n and μ_n are assumed to be normally distributed with zero mean and constant variance. McFadden and Train (2000) suggest a Lagrange Multiplier test to establish random versus fixed parameters. As noted by Hensher and Greene (2003), another way of testing for random parameters is to use a t -test on each estimated standard deviation, as is done here. Note that the distributional assumptions allow the parameters representing habits to take any sign. Household consumption can either be driven by habits or by variety-seeking behaviour (or none of them), such that the sign of these parameters is a matter of empirical investigation.¹⁶

Each day a household makes a breakfast cereal purchase constitutes a choice occasion. On each choice occasion, the households face prices of both the alternative purchased and the remaining choice alternatives. It is, therefore, necessary to measure the prices associated with all choice alternatives. Unfortunately, we only know the price at which the product purchased was bought, but not the prices of all alternatives faced by the household at that particular choice occasion. As a proxy for the price of the alternatives we use the average weekly

¹⁶ The choice of distribution is not evident; normal, as well as triangular and uniform, distributions allow the estimated parameters to take any sign. Hensher and Greene (2003) note that small differences in estimated moments (for models that assume parameters are normally, uniformly and triangularly distributed) have generally been found in empirical applications of MMNL models, which could imply that the choice among these three distributions may be of little importance. We also estimate the model assuming triangular and uniform distributions. The mean values of the estimated parameters are very similar over the different types of distributions, whereas the value of the estimated standard deviations is generally larger for the uniform (almost double) and triangular distributions (slightly more than double), and highly statistically significant, compared to the estimated standard deviations under the assumption that the parameters follow a normal distribution.

price of each alternative that was not purchased.¹⁷ Note that the price variable will, therefore, be affected by the composition of products purchased by the panel households in a particular week. Due to the potential measurement error in the prices associated with the alternatives not purchased, the estimates of the price parameter should be interpreted with caution.¹⁸

The model is estimated using *NLOGIT*, which is an extension of the econometrics computer program *Limdep*, and is especially developed to handle discrete choice models. Restrictions in *NLOGIT* allow a series of maximum 24 purchases for each household to be included in our model. In our sample, a relatively small share of the households (13 percent) made more than 24 purchases during 2003, i.e. are heavy breakfast consumers. Limiting the sample series of observations to a maximum of 24 for the heavy breakfast cereal consumers means running a risk of neglecting potential seasonal effects (structural changes) in breakfast cereal consumption. Therefore, to proceed with *NLOGIT*, we need to ensure that the risk of seasonal consumption for heavy breakfast cereal consumers is small, i.e. that the results will not depend on our sample of 24 observations chosen for these

¹⁷ Not all products have been purchased all days of the year. Therefore, average prices are calculated for each week, instead of average daily prices. Because the average prices are used for the alternatives that were not purchased and the actual prices are used for the alternative that was purchased, a relatively large price differences sometimes arises between the alternative chosen and the other alternatives. For example, an expensive product purchased in a convenience store is likely to be matched by relatively expensive alternatives – this will not be reflected by the average prices. Therefore, we have also estimated a variant of the model where the price of the observed choice is the average weekly price, instead of the observed price. The parameter estimates associated with the state dependence variables and constants are almost identical to the model described in the text. Even the estimate of the price parameter is similar to that presented in the text (which is based on the observed price) and highly statistically significant.

¹⁸ The measurement error associated with the price variable could potentially affect the other parameter estimates from the model. However, we find that the parameter values of the lagged choice variables are stable over a range of estimated model specifications, containing average or actual prices and different scale factors of the price variable. We interpret this to mean that the parameters for the lagged choice variables are little, if any, affected by the measurement error in the price variable.

households. To do so, we consider two different samples; one based on the first 24 purchases during the year for the heavy breakfast consumers and one based on the last 24 purchases. The results show that the parameter estimates are very similar, which imply little or no seasonal variation in breakfast cereal purchases. Formal tests of structural change in consumption over time will be weak due to dependency between the sub samples. Observations in series of either the first 24 or the last 24 purchases overlap for many heavy breakfast cereal consumers, and for those where there is no overlap of observations, the lags in the model cause dependency between the samples in the regressions. To decrease the dependency between the regressions, we estimated a model based on the first 12 observations, for the heavy breakfast cereal consumers, and another model based on the last 12 observations, for the same households. Thereafter, we perform a Wald-test for structural change, where the null hypothesis is that there is no difference in the parameters estimated by the two regressions. We cannot reject the null hypothesis. We conclude that the risk of seasonal effects in breakfast cereal consumption for heavy breakfast cereal consumers is small, and therefore choose to carry on the analysis by using *NLOGIT*. The results reported below are based on a sample series of the first 24 purchases during the year, for those households who purchased breakfast cereals more than 24 times during the study period.

The estimation results from the MMNL are shown in Columns 2-3 of Table 3,¹⁹ and t -values are shown within brackets.²⁰ For the random parameters, we estimated both the mean and standard deviations. The parameter estimates of the MMNL model in Table 3 provide information on the population profile, i.e. the distribution of parameter values across households purchasing breakfast cereals. Due to the statistically significant estimates of the standard deviations for both the alternative specific constants and the parameters associated with state dependence, our results imply heterogeneity in preferences over consumers. This is in line with the findings of several previous studies; e.g. Andersen (2006) Chidmi and Lopez (2007) Nevo (2001) and Chintagunta (1993) all report heterogeneity in preferences, and heterogeneity in state dependence, specifically, is found by e.g. Erdem (1996). A positive parameter estimate implies that utility increases as the corresponding variable increases and, thus, the probability of the household purchasing the product. Noteworthy is the pseudo-R² adjusted value of 0.40, suggesting a decent explanatory power.

¹⁹ The simulated maximum likelihood estimation was performed using the Standard Halton Sequence (SHS), which is a draw method that, compared to random draws, reduces the risk of drawing parameter values from a limited part of the specified distribution, and thereby reduces the number of draws needed for estimation (for details, see e.g. Train, 1999). Here, we make 100 Halton draws of β_n from its distribution $f(\beta_n|\theta)$. The number of iterations needed for model convergence is 61. To determine the overall statistical significance of the model, an LL-ratio test was performed, where the estimated model was compared to a model that includes the alternative specific constants only. The resulting χ^2 statistic equals 11,881 with 79 degrees of freedom, and the p -value is zero, implying that the estimated model significantly improves the log-likelihood function, compared to a model containing constants only.

²⁰ For comparison, we also report the results from a MNL model in the table, see column 1. The parameter values produced by the MNL are used as starting values for the simulated maximum likelihood estimation of the parameters of the MMNL model. The parameter estimates from the MNL model could also be regarded as a robustness test of the results. As shown, the qualitative results are the same in the MNL and the MMNL models.

The point estimate of the price parameter is negative and statistically significant, suggesting that the typical household in the sample experiences a decrease in utility (and hence a negative effect on the probability of purchasing a breakfast cereal) from a marginal increase in the price of this particular breakfast cereal.²¹ Also, the results show that, on average, having purchased the particular breakfast cereal type on the previous or second previous choice occasion positively affects the utility of the particular breakfast cereal, implying habit persistence in breakfast cereal consumption. We also find statistically significant heterogeneity in the response of households, suggesting that households differ from the population mean.

Based on the results in columns 2-3, we calculate the marginal utility effects of having chosen this particular cereal on the previous and second previous choice occasions. The sample distributions of marginal effects from the previous choices are presented in Figure 1B and 2B in Appendix B.²² Figure 1B shows that the consumption by the majority of households is associated with habit persistence (the marginal utility of having purchased a breakfast cereal type on the previous choice occasion is positive), but that there are households that value variety as well, i.e. for whom the marginal utility of having purchased a breakfast cereal on previous choice occasions is negative. As shown by Figure 2B, the marginal effects of having purchased a product two choice occasions ago are very similar to those of having purchased the product on the previous choice occasion.

²¹ Our results imply that a SEK 10 increase in the price per 100 gram of flakes reduces the choice probability of flakes by 0.1 percentage points. Correspondingly, a SEK 10 increase in the price of Keyhole labelled cereals reduces the choice probability for Keyhole labelled cereals by 0.04 percentage points; a SEK 10 increase in the price of muesli reduces the choice probability for muesli by 0.07 percentage points, a SEK 10 increase in the price of sweet cereals reduces the choice probability for sweet cereals by 0.05 percentage points, and, finally; a SEK 10 increase in the price of “others” reduces the choice probability for “others” by 0.03 percentage points.

²² The formula used for calculating the marginal utility is $\bar{\beta} + \sigma \times N$, where $\bar{\beta}$ is the mean estimate, σ is the standard deviation and N has a standard normal distribution.

The finding of relatively strong habit persistence is in line with previous studies based on disaggregate product data. The absolute value of the parameter estimates found here are, however, not directly comparable to results in previous studies, both because previous studies only include one lag of the choice variable, and because model specifications are slightly different. For instance, Sun et al., 2003, include a dummy for the most recent lagged choice and, depending on the model specification, find estimates of structural state dependence ranging between 1.76 and 2.40 for ketchup, which is higher than the mean estimates presented here for the previous choice occasion.

We also attempt to explain (at least part of) the variation in state dependence across consumers, and to distinguish observed differences in state dependence from other sources of preference heterogeneity. We do so by interacting both the constant and the state dependence variables with observed household characteristics (income, education, as well as number of children and adults). More specifically, we try to identify the household types with characteristics that affect the utility associated with the particular breakfast cereal, as well as the household types whose consumption exhibits particularly strong habit persistence. We thereby allow for different mean parameters over household groups. The omitted groups are Lowest income, Elementary schooling and Single. The results are shown in columns 2-3 of Table 3 below. Parameter estimates that are not statistically significant at the 10 percent level are not reported here.

The parameter estimates associated with the interaction terms between the measures of state dependence and household characteristics are generally not statistically significant. The exception is that the utility of choosing a breakfast cereal seems to be less affected by having purchased the cereal on previous choice occasions if the household consists of two adults with children (both one child and

two or more children) than if the household consists of a single adult with no children. Also, households with high school education and higher education seem to be less affected by the purchase on previous choice occasions, compared to households with the lowest education. The strength of the habit persistence does not seem to be affected by income.

Regarding the interaction terms between the alternative specific constants and the household characteristics, the results suggest that the utility from sweet breakfast cereals is positively affected if the household includes children. Adding more adults to the household seems to have a negative effect on the utility derived from Keyhole-labelled breakfast cereals. For muesli, the qualitative findings are the same as for Keyhole-labelled breakfast cereals. In addition, it seems that the utility of choosing muesli is positively affected if the person responsible for food purchases has a high school or higher education. Also, households belonging to the highest income group derive a higher utility from choosing muesli than low-income households.

Table 3. Utility parameter estimates

Variable	Model		
	Multinomial logit model	Mixed multinomial logit model with household characteristics	
	Estimated parameters	Estimated mean value	Estimated std dev
P	-1.227*** (-7.891)	-1.425*** (-24.481)	
$D_{ppj,t-1}$	1.013*** (40.020)	0.853*** (6.828)	0.588*** (11.154)
$D_{ppj,t-2}$	1.132*** (45.277)	0.826*** (6.591)	0.515*** (10.838)
<i>Alternative specific constants</i>			
$\alpha_{Keyhole}$	-0.782*** (-16.804)	-1.709*** (-6.530)	1.923*** (16.429)
α_{musli}	-0.062* (-1.767)	-0.327* (-1.893)	1.424*** (21.589)
α_{others}	-1.170*** (-20.730)	-2.218*** (-7.812)	1.314*** (12.983)
α_{sweet}	-0.467*** (-10.414)	-2.072*** (-7.530)	1.648*** (17.563)
<i>Interactions with household characteristics</i>			
$\alpha_{Keyhole} \times 3 \text{ Adults}$		-0.778** (-2.265)	
$\alpha_{Keyhole} \times 2 \text{ Adults}$		-0.620** (-2.292)	
$\alpha_{musli} \times \text{Income gr 3}$		0.429** (2.087)	
$\alpha_{musli} \times 3 \text{ Adults}$		-0.583*** (-2.631)	
$\alpha_{musli} \times 2 \text{ Adults}$		-0.392** (-2.110)	
$\alpha_{musli} \times 2 \text{ Adults, 2 C}$		-0.670*** (-3.172)	
$\alpha_{musli} \times \text{Education2}$		0.352*** (2.618)	
$\alpha_{musli} \times \text{Education3}$		0.324*** (2.236)	
$\alpha_{others} \times \text{Income gr 4}$		-0.719* (-1.855)	
$\alpha_{others} \times 2 \text{ Adult, 1 C}$		1.120*** (3.128)	

Table 3 continued:

$\alpha_{others} \times 2 \text{ Adult, } 2 \text{ C}$	0.739** (2.422)	
$\alpha_{sweet} \times 3 \text{ Adults}$	1.269*** (3.984)	
$\alpha_{sweet} \times 2 \text{ Adults, } 1 \text{ C}$	1.814*** (4.647)	
$\alpha_{sweet} \times 2 \text{ Adults, } 2 \text{ C}$	2.312*** (6.921)	
$\alpha_{sweet} \times 1 \text{ Adult w C}$	2.590*** (7.185)	
$D_{pp1} \times 2 \text{ Adults, } 2 \text{ C}$	-0.353*** (-2.171)	
$D_{pp1} \times \text{Education2}$	-0.231** (-2.205)	
$D_{pp2} \times 2 \text{ Adults, } 2 \text{ C}$	-0.291* (-1.707)	
$D_{pp2} \times 1 \text{ Adult w C}$	-0.459** (-2.158)	
$D_{pp2} \times \text{Education2}$	-0.188* (-1.864)	
$D_{pp2} \times \text{Education3}$	-0.256** (-2.312)	
Pseudo R-squared adjusted	0.23	0.40

Superscripts ***, ** and * imply statistical significance at the 1, 5 and 10 percent level, respectively.

A range of alternative models were also estimated, where the alternative specific constants are fixed and the parameters associated with state dependence are random (with and without being interacted with household characteristics), and models where the alternative specific constants are random and the parameters associated with state dependence are fixed (with and without being interacted with household characteristics). The comparable qualitative findings remain, and we conclude that the findings reported in Table 3 appear to be robust.

5. Discussion

We estimate the strength and heterogeneity over households in state dependence associated with breakfast cereal consumption, where positive state dependence implies habit persistence and negative state dependence implies variety-seeking in breakfast cereal consumption. Our results suggest that habits are a very important determinant of breakfast cereal choices. There seems to be a strong element of habit persistence in breakfast cereal choices for all breakfast cereal types. In addition, our results suggest that there is a significant variation across households in the strength of habit persistence, meaning that single (mean) parameters representing state dependence are insufficient in representing household behavior. Consumption by the average household is strongly habitual, but there are households where consumption is better described as variety-seeking.

The relative shares of consumption of the breakfast cereal types seem to be similar over income and educational groups. However, households with many children have a higher consumption of sweet cereals and lower consumption of Keyhole-labelled breakfast cereals than households with no children. If aiming at improving the nutritional quality of breakfasts, households with many children might therefore be a target group.

We also add interaction variables between the measure of state dependence and observed household characteristics, such as income, education and the number of children and adults in the household. The idea is to examine (as far as the data allow) whether differences in state dependence can be attributed to observed characteristics. In general, these interaction effects have little influence on the choice of breakfast cereals, suggesting that it may be necessary to look beyond these characteristics in order to explain differences in the strength of state dependence. Habit persistence appears to be the weakest for two-adult households

with children compared to single-adult households without children. This could be an indicator of habit persistence being weaker for households with children, compared to those without. However, the comparison of relative strength of habit persistence over household types should be interpreted with caution. Habit persistence as defined here may also reflect a greater preference heterogeneity within households with more individuals and both adults and children (relative to households consisting of adults only), and not necessarily weaker habit persistence for single individuals in the household.

Our results support the literature that finds habit persistence in food consumption. Typically, habit persistence is found in data sets containing disaggregated product data and, to a lesser extent, when habit persistence is analyzed using more aggregate product data. Our results imply that the “stickiness” of consumption (habit persistence) should be taken into account when developing policies to address consumption of certain food categories. For instance, consumer response to tax reforms (e.g. subsidizing Keyhole-labelled foods), or information campaigns aimed at encouraging a healthier food consumption, will be affected by the degree of habit persistence associated with both the Keyhole-labelled foods and the less healthy substitutes. The higher the degree of habit persistence, the larger the difference between short and long term consumer responses to permanent relative price changes, and the more forceful the policy instruments need to be in order to redirect consumption in the short run.

The estimated price parameter is relatively small, implying that the probability of purchasing breakfast cereals is little affected by price changes. This might be due to breakfast cereals being a relatively inexpensive product that represents only a small budget share (see Nordström and Thunström, 2008), such that households pay little attention to price increases in breakfast cereals.

Important issues for future research are to extend the analysis to include a wider range of food groups, in order to gain information on differences in habit persistence associated with consumption of particularly healthy food products and unhealthy food products. Here, the analysis could be based both on habit persistence in consumption of specific nutrients, as well as in products. It would also be of interest to analyze the extent to which habits stick over the consumer's life cycle. Finally, it would be valuable to gain information on what policies (i.e. price or information mechanisms) are most effective in influencing consumption associated with habit persistence. Here, experimental methods (e.g. choice experiments) may be helpful. All these issues are important for policy makers to understand when designing policies aimed at encouraging a healthier food consumption.

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Appendix A

Table A1. Variable definitions

Variable name	Definition
Price	Price per 100 gram of the product purchased for the observed choice, average weekly price per 100 gram for the alternatives. Prices are in SEK (expressed in units of SEK divided by 10)*
$D_{ppj,t-1}$	1 if the breakfast cereal type was purchased on the last consecutive choice occasion, zero otherwise
$D_{ppj,t-2}$	1 if the breakfast cereal type was purchased on the second last consecutive choice occasion, zero otherwise
Single	1 for households consisting of a single adult without children, zero otherwise
2 Adults	1 for households consisting of two adults without children, zero otherwise
Single with Children	1 for households consisting of a single adult with one or more children, zero otherwise
2 Adults, 1 Child	1 for households consisting of two adults with one child, zero otherwise
2 Adults, 2 Children	1 for households consisting of two adults and two or more children, zero otherwise
3 Adults	1 for households consisting of three or more adults, zero otherwise
Elementary schooling	1 for households where the maximum level of education for the person mainly responsible for food purchases is elementary schooling, zero otherwise
High school education	1 for households where the maximum level of education for the person mainly responsible for food purchases is high school education, zero otherwise

Table A1 continued:

Higher education	1 for households where the maximum level of education for the person mainly responsible for food purchases is university education, zero otherwise
Education,na	1 if household has not reported the level of education, zero otherwise
Income group 1 (lowest)	1 for households with maximum yearly income of SEK 199,999, zero otherwise
Income group 2	1 for households with yearly income SEK 200,000-299,999, zero otherwise
Income group 3	1 for households with yearly income SEK 300,000-499,999, zero otherwise
Income group 4 (highest)	1 for households with yearly income of minimum SEK 500,000, zero otherwise

* On January 10th 2008, USD/SEK = 6.36. Prices are calculated as the average price of all products, in each of the five categories, purchased by the households in the sample in a given week.

Table A2. Relative share of household types in the sample, compared to the sample in the full GfK panel of grain consumers (who stayed in the panel for the full year)

Variable name	Relative share of those purchasing breakfast cereals	Relative share of the full GfK panel for 2003
Single	0.29	0.36
2 Adults	0.37	0.36
Single with Children	0.04	0.03
2 Adults, 1 Child	0.06	0.06
2 Adults, 2 Children	0.11	0.08
3 Adults	0.13	0.11
<i>Sum</i>	<i>1.00</i>	<i>1.00</i>
Elementary schooling	0.28	0.33
High school education	0.43	0.40
Higher education	0.29	0.26
Education,na	0.01	0.01
<i>Sum</i>	<i>1.00</i>	<i>1.00</i>
Income group 1 (lowest)	0.25	0.30
Income group 2 (2 nd lowest)	0.26	0.26
Income group 3 (2 nd highest)	0.35	0.29
Income group 4 (highest)	0.14	0.11
<i>Sum</i>	<i>1.00</i>	<i>1.00</i>

Appendix B

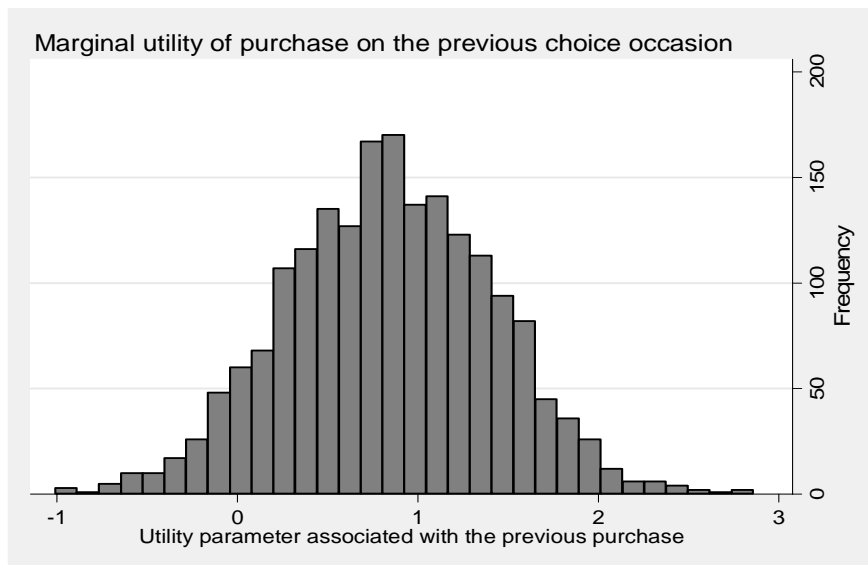


Figure 1B. Estimated distribution of the coefficient for purchase on the previous choice occasion

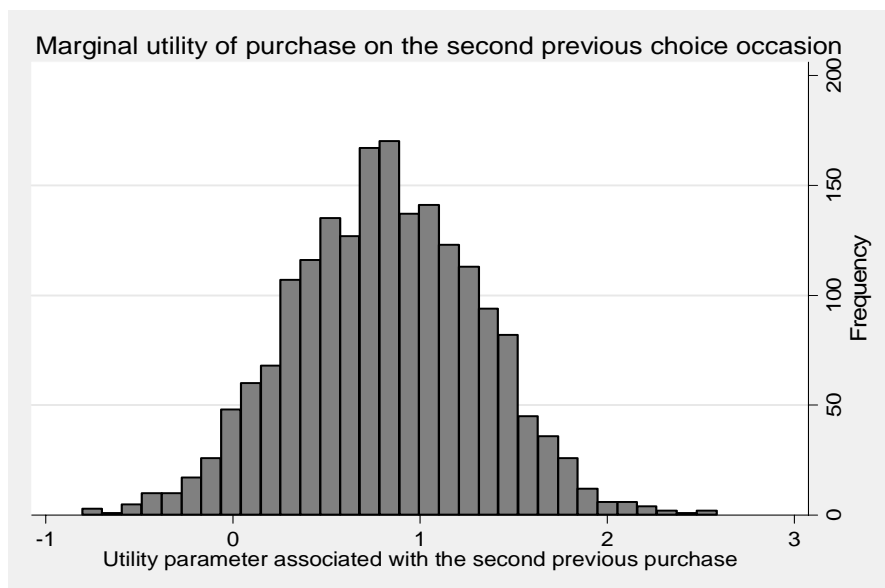


Figure 2B. Estimated distribution of the coefficient for purchase on the second previous choice occasion

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